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Technical Report 900

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# Crew Performance Associated with the Simulation of the Commander's Independent Thermal Viewer (CITV)

Kathleen A. Quinkert  
U.S. Army Research Institute

July 1990

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**Technical Report 900**

**Crew Performance Associated  
with the Simulation of the Commander's Independent  
Thermal Viewer (CITV)**

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## FOREWORD

The Fort Knox Field Unit of the U.S. Army Research Institute (ARI) has a well-established and productive program of research in the area of Training Requirements for the Future Integrated Battlefield. Work conducted under this program is supported by Memoranda of Understanding (MOUs) with the U.S. Army Armor School (USAARMS) and the U.S. Army Tank-Automotive Command (TACOM).

This technical report presents the results of an experimental effort that examines the operational effectiveness, predicted training, and the soldier-machine interface issues associated with the Commander's Independent Thermal Viewer (CITV). The CITV is a preplanned product improvement for the M1 Abrams main battle tank. This research provides early information to the combat and training developers responsible for the development of the CITV.

The effort has been briefed to the Commanding General (CG) of Fort Knox (22 June 1989), the USAARMS Directorate of Combat Developments (DCD) (26 August 1988), the Project Manager Abrams (July 1988), and the Project Manager Training Devices (30 September 1988). Preliminary results of the research effort were used by DCD to brief the CG, U.S. Army Training and Doctrine Command (TRADOC), CG, U.S. Army Materiel Command (AMC), Deputy Under Secretary of the Army-Operational Research (DUSA-ORA), and the Chief of Staff, U.S. Army (CSA).

  
EDGAR M. JOHNSON  
Technical Director



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# CREW PERFORMANCE ASSOCIATED WITH THE SIMULATION OF THE COMMANDER'S INDEPENDENT THERMAL VIEWER (CITV)

## EXECUTIVE SUMMARY

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### Requirement:

The U.S. Army is considering the acquisition of the Commander's Independent Thermal Viewer (CITV). This system is a pre-planned product improvement for the M1 Abrams. The research herein was focused on a twofold requirement. The first requirement is to assess the operational effectiveness of the CITV, as it relates to tank gunnery. The second requirement is to identify potential soldier performance problems that should be addressed via equipment design, future training devices, and training programs. The first portion of this requirement was raised by the Directorate of Combat Developments (DCD) and the Weapons Department at the U.S. Army Armor School (USAARMS) raised the issue to address the effectiveness of the CITV. This requirement was echoed by the Project Manager (PM) Abrams. The second portion of the requirement was surfaced by Project Manager Training Devices (PM TRADE). This requirement is related to soldier performance issues resulting from engineering design and to training issues pertaining to expected changes in the current M1A1 training program.

### Procedure:

Forty tank commander (TC)-gunner pairs, classified as 19K, were randomly assigned to one of two groups--CITV and No CITV. Testing in the CITV group was conducted in an existing training device, the Unit-Conduct of Fire Trainer (U-COFT), that was modified to include a prototype Commander's Independent Thermal Viewer (CITV). Testing for the No CITV group was conducted under the same conditions but with an unmodified U-COFT. Soldiers were tested on eight modified U-COFT scenarios where measures of speed, accuracy, and quantity were collected. Subjective information was also collected from the TCs to assess the difficulties in learning to use the system, the problems associated with the design of the system, and the workload associated with the use of the CITV.

### Findings:

The analyses indicate that TC-gunner pairs using the CITV significantly differed from the No CITV group in the number of

targets detected and subsequently killed. There was also a significant difference in the amount of time taken to detect and kill these targets. TCs, in general, voiced dislike of the system design as it related to the commander's control handle. There were indications given that the addition of the CITV would require crew training programs that place greater emphasis on TC and gunner coordination. This was deemed necessary to optimize the CITV speed payoff. The TCs also rated the CITV as manageable with respect to the physical workload and cognitive information loading.

#### Utilization of Findings:

The results of this research served as a basis for an analysis of the operational effectiveness of the CITV. They provided examples of poor soldier-machine interface that affected the performance of the TC and highlighted problematic areas associated with training. These results were briefed to the Commanding General (CG) at Fort Knox, the USAARMS DCD, the PM Abrams, and the PM TRADE. Preliminary results of the research effort were briefed to the Deputy Under Secretary of the Army-Operational Research (DUSA-ORA) and used by DCD in decision briefings for the CG, U.S. Army Training and Doctrine Command (TRADOC), CG, U.S. Army Materiel Command (AMC), and the Chief of Staff of the U.S. Army.

CREW PERFORMANCE ASSOCIATED WITH THE SIMULATION OF THE  
COMMANDER'S INDEPENDENT THERMAL VIEW (CITV)

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CREW PERFORMANCE ASSOCIATED WITH THE SIMULATION  
OF THE COMMANDER'S INDEPENDENT THERMAL VIEWER (CITV)

Introduction

Block II Improvements to the M1A1 Main Battle Tank

As the M1 main battle tank was developed, tested, and produced, there were several improvements that were identified and documented. These improvements were arranged in blocks to ensure a continuous update to the tank. The first block improvement, known as the M1A1, was fielded in 1986. The M1A1 included a 120mm main gun, additional armor on the front slope of the chassis, and an over-pressurization system for nuclear, biological, and chemical (NBC) protection. The second block (Block II or M1A2) of improvements, originally slated for production in FY92, included seven components. These were the survivability enhancement (SE) package, the improved commander's weapon station (ICWS), a CO2 laser rangefinder (CO2 LRF), a commander's independent thermal viewer (CITV), a driver's thermal viewer (DTV), and a battlefield management system (BMS)<sup>1</sup> to include position location and heading reference system (POS/NAV).

To date, component testing and/or limited implementation has occurred for the SE package, the CO2 LRF, the ICWS, and the DTV. Of the remaining components, the CITV is currently the U.S. Army Armor School's (USAARMS) highest priority for fielding in the M1A2 program. Some government and contractor testing of the CITV concept has occurred; but little soldier-related performance testing has been accomplished (Parker & Johnson, 1988). This lack of soldier testing is certainly not unusual, as many new Army systems have been fielded without early consideration of the soldier. However, this system has been identified early in the literature (Hyman, 1987; Quinkert, 1987; Quinkert, 1988; and Schaad & Steinberg, 1988) as one with a high likelihood of poor soldier-system fit. This poor fit is centered on the expected additional workload, information flow, the disorientation problem associated with indirect viewing, and changes in the current training strategy that would be necessary to integrate the CITV into the M1A1. These soldier issues related directly to the usability and overall effectiveness of the CITV; therefore they became the objectives of a research effort, part of which will be described herein.

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<sup>1</sup>The battlefield management system (BMS) was the original terminology for the Block II program. Recently, the scope of this system has been downgraded and referred to as the inter-vehicular information system (IVIS). The IVIS terminology will be used in the remainder of this document.

## Commander's Independent Thermal Viewer (CITV)

The CITV was originally proposed as an integral component of the automated command and control capability, IVIS. The CITV was envisioned as the "eyes" of the system and those eyes were thought to be profoundly important on the future battlefield where conditions of darkness, heavy concentrations of artillery, and increasing degradation of battlefield visibility would prevail. When fully integrated into the command and control system the CITV was the sighting mechanism, the position navigation was the locating mechanism, and the IVIS was the transmitter and receiver of battlefield information. This integration would also meet the longstanding requirement for the capability to quickly detect and engage multiple enemy targets. However, due to funding constraints, the acquisition plan for the Block II was fragmented. This fragmentation resulted in the singular acquisitions of the CITV, POS/NAV, and IVIS. That is, the CITV is not physically integrated with either the position location system or the IVIS. Therefore, the battlefield information that could have been automatically transferred through the IVIS system now becomes additional information that a tank commander (TC) must assimilate to make decisions.

The CITV is to be a separate and independent thermal imaging system designed for the use of the TC. This system makes use of the forward looking infrared (FLIR) technology, housed in an external sensor mounted on the left front of the turret (Figure 1). As implied by the name, it is designed to be stabilized independent of both the turret and hull movements. The CITV is designed to operate within the 8-14 micron range of the electromagnetic spectrum and can be used by the TC in either a closed or open hatch mode. As described by Spears (1987), the CITV provides the commander with a previously unavailable opportunity for independent surveillance and target acquisition. This opportunity allows the commander an expanded view of the battlefield that should enable him to move and shoot more efficiently and effectively. This will be particularly true in situations where the battlefield is obscured by man-made obscurants such as smoke, or by environmental conditions such as darkness and fog. This independent surveillance and target acquisition capability, as depicted in Figure 1, gives the TC at least 270 degrees of unobstructed horizontal field of regard. In addition to the horizontal viewing, the CITV provides a vertical range of +20 degrees to -12 degrees. The CITV is to be an integral component of the M1A2 fire control system, providing a backup sighting capability for firing the main gun.

There are many advantages associated with the use of the CITV. The TC equipped with a CITV can independently search a predetermined sector, identify and hand off targets to the gunner by designating the target location and automatically slewing the main and gunner's reticle to the target area. Theoretically, the

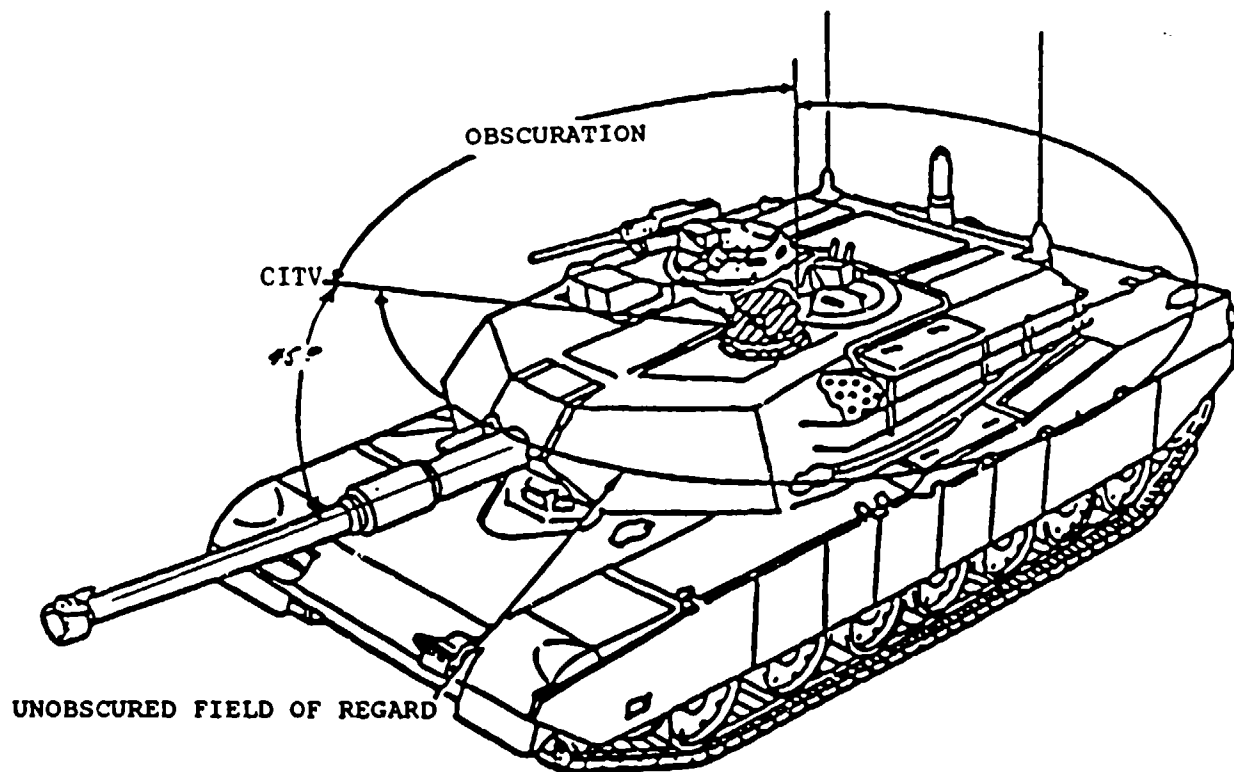


Figure 1. CITV field of regard.

commander can then continue his independent search for additional targets. The gunner's job then becomes one of finalizing the lay, firing the main gun, and making the final kill assessment.

When the engagement is completed, the gunner could be slewed to a new target position by the commander or he could continue to search in his predetermined sector which, in all likelihood, would differ from that of the TC. This approach to independent search and automated target handoff has been referred to as the Hunter-Killer concept.

The impact of the Hunter-Killer capability on the TC and gunner activities has been described on several occasions. The depiction used by Smits and Boismier (1987) describes the TC-gunner interface better than most. As shown in Figure 2, the current M1A1 configuration (without CITV) requires TC-gunner dependency. That is, at the most critical points of the gunnery sequence, either the TC or the gunner must wait until the other has completed an action before a new action can take place. An example of this dependency is when the TC is actively searching and identifying targets using the commander's override. During this time the TC is in control of the movement of the turret and main gun and the gunner can not actively search for targets and is reduced to the role of an observer. Following this gunnery sequence, when the TC hands-off a target to the gunner, he now relinquishes movement control of the turret and the main gun. As the gunner goes about his business of laying on the target, lasing and firing, the TC now takes on the role of the observer. He does not actively participate in this action but must remain affixed to the gunner's primary sight extension (GPSE) in order to assess the damage to the target.

The CITV allows concurrent activity of the TC and gunner with the added benefit of magnified sights. When the TC has decided that a target should be engaged, he designates the target to the gunner. While the gunner is acquiring and engaging the target, the TC can resume independent surveillance. When the gunner completes the engagement, he can be immediately brought to a new target if the TC has designated one, or the gunner can resume surveillance in his own assigned sector.

The major payoff of this Hunter-Killer capability is expected in the reduction in time for a tank crew to detect and engage targets in the crew's field of responsibility. It is also expected that with this decrease in time an increase in the number of targets a crew can acquire should follow. In addition to helping the crew service multiple targets quicker, it has been hypothesized that the crew may also be able to fight "smarter". In a high density threat environment, the TC must be aware of the threats against him and decide the order in which the targets are to be engaged. This is logically based upon threat type, range, opportunity to engage, and so forth. In the dynamic environment expected on the next battlefield, this order can change rapidly. Therefore, it follows that the greater the opportunity for the crew to conduct surveillance, the more accurate will be the

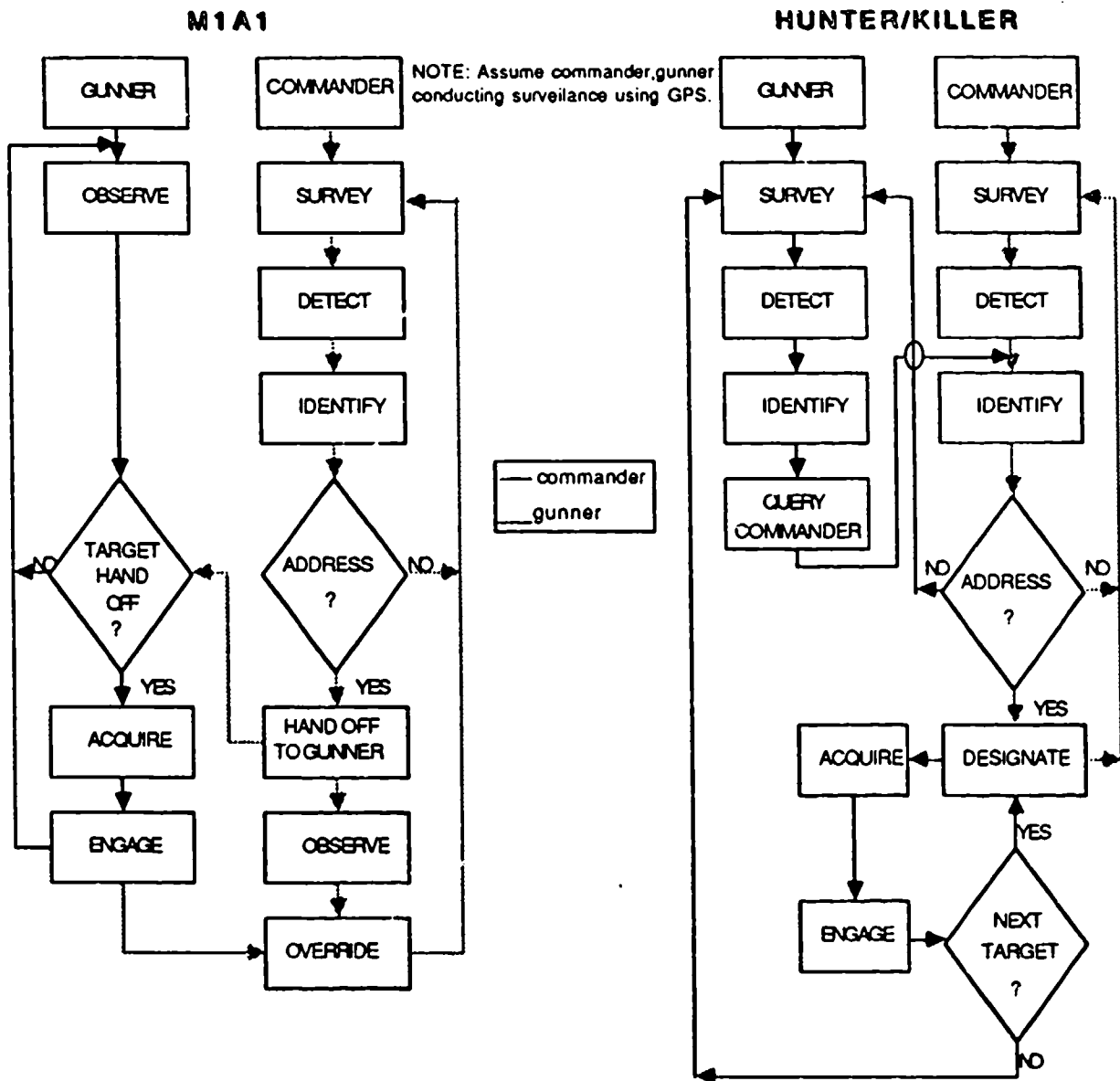


Figure 2. M1A1 and M1A2 gunnery sequence comparison.

assessment of the overall threat. These changes are expected to significantly alter indices such as the loss exchange ratio.

The concept of the CITV is certainly not novel or complex (Quinkert, 1987). In fact, it has been described by some as a rather simple application of technology. Additionally, versions of the CITV have been very successfully employed in other main battle tanks. For example, the German Leopard 2 and the Korean ROK have independent panoramic sights. The CITV, according to the system specifications (General Dynamics Land Systems, 1985), requires only three operational modes. The first allows the commander to independently survey the battlefield, either with an automatic scan or a manual search. The second (Hunter-Killer) slaves the turret and main gun to the CITV line of sight (LOS). The third (gun line of sight (GLOS)) slaves the CITV to the main gun sight in order for the commander to monitor or check the priority of a target. The GLOS is a redundant mode as the TC can also monitor or check priorities in his GPSE. Because of these limited functions and the few new tasks projected for this system, many advocates of the CITV believe that there should be few problems associated with the use of this system.

Despite the advertised simplicity of this concept, however, the implementation of the concept has the potential for high levels of operator complexity (Hyman, 1987; Quinkert, 1987; Schaad et al., 1988). There are several major issues that feed this complexity, all of which should be addressed before a CITV interface design is finalized and the system is fielded. The majority of these issues are concerned with the system design requirements and the resulting mission demands which may overload the commander during critical phases on the battlefield. These issues include, but are not limited to: (a) the soldier-machine-interface (SMI) design and its associated operator workload; (b) the need for changes in existing crew behaviors, such as fire control commands and in assigned responsibilities, such as target assessment; (c) the need for changes in existing doctrine to maximize the capability of the CITV; and (d) the ramifications of these changes for individual and collective training programs.

The SMI issues associated with the use of an indirect viewing have been well documented in the Surrogate Research Vehicle (SRV) efforts conducted at Ft Knox by the U.S. Army Armor and Engineer Board (USAARENB) in 1984 and again in 1988. The SRV effort was designed to provide information about the crew's capability to acquire and engage targets with improved sight systems, control and display panels, target file system, and automatic target cueing system. The SRV was fitted with electro-optical packages that included color, black and white, and thermal cameras mounted on two axis (TC and Gunner) stabilized platforms. These platforms were referred to as stagets and could be traversed 360 degrees, elevated +30 degrees and depressed to -15 degrees. These characteristics are not drastically different from the characteristics of the CITV sensor.



The SRV effort is most useful in the CITV research because, in both cases, information was gathered from an external sight and projected onto a two dimensional screen for viewing by the TC. This procedure is very similar to that proposed for the CITV. Figure 3 gives an indication of the planned placement of the CITV inside the turret area of the tank and the approximate workstation area of the TC, to include the commander's control handle that is redesigned to support the operation of the CITV.

The results of the original SRV research (Dedmon & Mielec, 1984) were alarming to those who expected ease of use in the indirect viewing system. It was quickly found that users could not get the proper depth perception on a two dimensional screen and many navigational errors made by the crew were attributed to improper sensory-perceptual cues. Additionally, it was found that users simply got misoriented or lost inside the tank. This was attributed to the lack of knowledge provided to the TC about the directional movement of the hull in relation to the movement of the staget sight and turret. The second SRV effort (Skurski & Parker, 1988) indicated that some of the misorientation could be corrected with a hull reference indicator provided to the TC. The underlying concern present in both of these efforts should serve as a referent to those designing the display of the CITV. That referent is, the cues a TC receives from a flat 2-dimensional screen will be significantly different from those he is used to receiving from a direct sight. Therefore, problems associated with the accurate use of the system may be expected. Also, there is a likelihood that unless the TC is provided with an accurate reference symbol indicating the relationship between the important component of his vehicle (hull, turret, and CITV) there is the distinct possibility that the TC will get lost inside the turret. Issues such as these are exemplary of those which fall into the domains of a U.S. Army program called Manpower and Personnel Integration (MANPRINT), and have been identified in the M1A2 System MANPRINT Management Plan (SMMP).

#### Manpower and Personnel Integration - MANPRINT

The guidance for the MANPRINT program is included under Army Regulation 602-2 (1986), and its primary goal is to improve total system (soldier and equipment) performance by the continuous integration of Manpower, Personnel, Training, Human Factors Engineering, System Safety and Health Hazard consideration throughout the life cycle of the system (U.S. Army, 1986). As a result of this regulation, the combat, materiel, and training developers are now faced with ensuring, early in the life cycle of the system, that the design is driven through constant consideration of the soldier (operator, maintainer, and supporter). While the MANPRINT program makes great common sense, the immediacy of its imposition on the Army community has left many responsible agencies in a quandary as to how to "accomplish" MANPRINT.

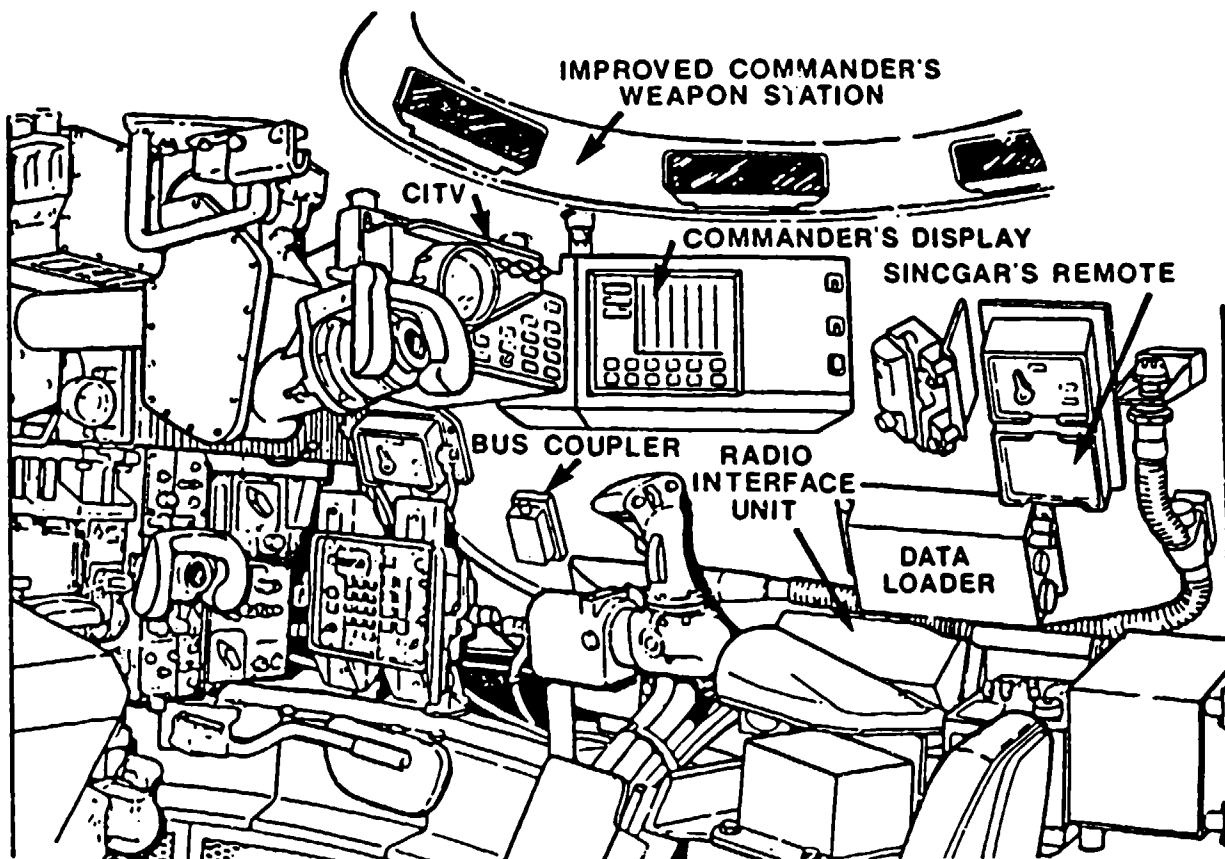


Figure 3. Internal view of the M1A1 depicting selected components of the M1A2.

An immediate response is to turn to the test and evaluation arena for analytical assistance. Common suggestions for this assistance include simulation models and field tests. While both of these methods are needed in the acquisition cycle, they do not meet the needs of the MANPRINT program. The simulation models, which are considered adequate for front-end analyses of the equipment, rarely make provisions for the consideration of the human element. In a similar light, field tests which include the human element have proven very costly and perhaps too untimely for their results to affect the ultimate design of the system. So, in effect, this new regulation is a large marching order, given that necessary tools are either non-existent or in the best case - under development.

In an attempt to provide a portion of soldier-in-the-loop front-end analysis, the Unit-Conduct of Fire Trainer (U-COFT) was modified with a CITV and research was performed to experimentally address soldier performance issues associated with the use of the CITV.

#### Unit-Conduct of Fire Trainer (U-COFT)

The Unit-Conduct of Fire Trainer (U-COFT) is a high-fidelity tank simulator developed for the U.S. Army and is currently used to meet the need for a M1 gunnery trainer. U-COFT was designed to train and sustain gunnery proficiency by allowing commanders and gunners (as TC-gunner pairs) to perform gunnery tasks under conditions that may be encountered in combat (General Electric Company, 1985).

Often considered strictly a training device, the U-COFT has become a valuable research tool in the recent past. It has been used to measure soldier performance on a full range of tank gunnery related tasks and to address research issues such as: (a) validation of gunners selection tests (Graham, 1986), (b) validation of psychomotor and perceptual predictors of Armor officer performance (Smith & Graham, 1987), (c) the effects of NBC equipment on soldier performance (Abel, 1987), and (d) the effects of degraded mode gunnery procedures on gunner performance (Witmer, 1988). These research efforts required collection of speed and accuracy measurements associated with the performance of such tasks as target acquisition, main gun lay, and issuing of fire commands.

U.S. Army Research Institute Field Unit-Knox (ARI-Knox) and the Armor School, in cooperation with Project Manager Training Devices (PM TRADE), arranged for the modification of a U-COFT that provided the capability to explore the effectiveness of the CITV and the possible SMI problems with the soldier in the testing loop. This research was conducted before the contractor's final CITV design was completed so that the user community could better explain their requirements for the CITV. The specifications for the simulation requirements were based on ARI-Knox efforts (Quinkert, 1988) as were the software modifications pertaining to the experimental scenarios and

automated data collection. The Weapons Department of the U.S. Army Armor School approved the design and PM TRADE contracted General Electric for the production prototype and modifications to the current U-COFT hardware and software.

#### U-COFT/CITV Design

As shown in Figure 3, the CITV display is located directly in front of the TC and to the immediate right of the GPSE. This position allows appropriate viewing of the display, easy access to the control buttons, and good transition capability from the CITV display to the GPSE. For this research effort the display and controls were considered one unit. This unit is shown in Figure 4. The description of each function is found in Appendix A. The orientation icon provided for the TC use is shown in Figure 5. It was located bottom center on the CITV display and provided information about the position of the turret/gun and CITV in relation to the hull. That is, the hull portion of the icon remained stationary, with the turret/gun and CITV moving. This movement took into account any change in the hull, turret/gun or the CITV. This version of the CITV included reticles for 3X and 10X magnification. These are shown in Figure 6. The CITV also requires a modification to the commander's control handle. This modification, shown in Figure 7, allows the TC to manually search with the CITV sensor. It also allows him to change operational modes (e.g., GPSE versus CITV) without having to reach to the control panel. This is accomplished by the rocker switch positioned on the head of the handle.

The CITV modification required a change in the U-COFT sighting system. The channel normally used for the forward unity periscope (FUP) and Caliber 50 sight was allocated for the CITV. Therefore, there was no Caliber 50 sight or FUP for the TC's use.

Software modifications to the U-COFT system were also necessary. These changes include modified U-COFT exercises and performance measuring system. The former necessitated exercises comprised of target rich environments and targets that were widely dispersed. It was stipulated in the specifications that the number of targets would be increased (2, 3, or 4 targets per engagement) and that no target would be farther than 90° from another target. This modification allowed a good test of the soldier's capability to use the CITV appropriately. The latter included a performance measuring system to facilitate the use of the CITV. It was stipulated in the specifications that this system would allow the measurement of the TC's target identification time while using the CITV. This time was defined as the time from full target exposure to the time the center of the CITV 10 power reticle was within 2° of the target. Target designation time was also to be collected. This measure was defined as the time from full target exposure to activation of the designate button on the commander's control handle.

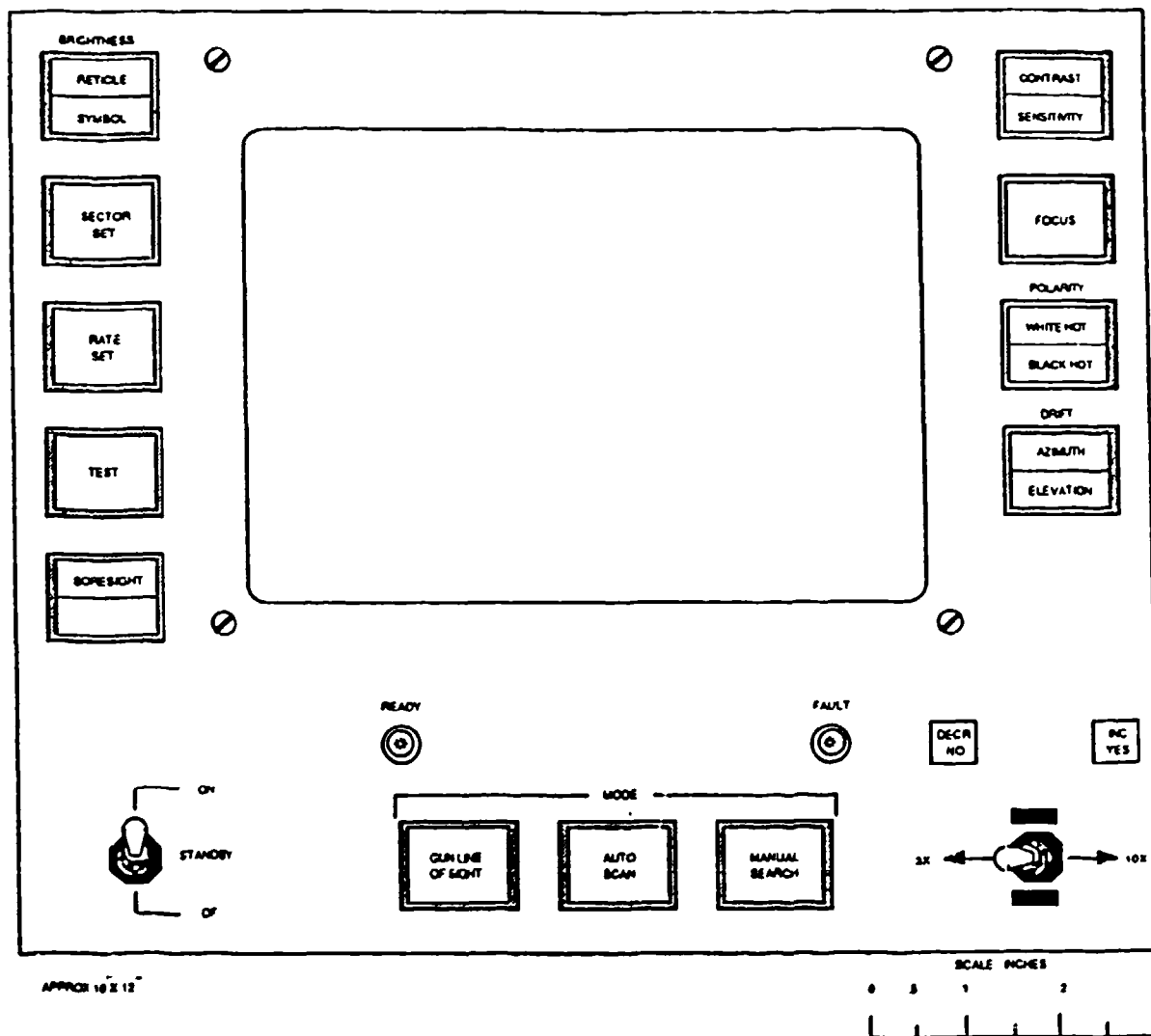
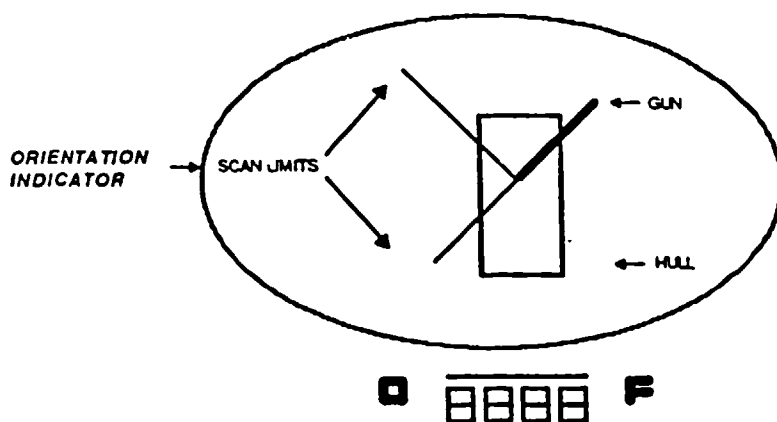


Figure 4. CITV display and control panel.



SYMBOLS:

1. ——— MULTIPLE RETURNS
2. □□□□ RANGE
3. F MALFUNCTION
4. □ READY TO FIRE

Figure 5. Orientation icon as seen in CITV sight picture.

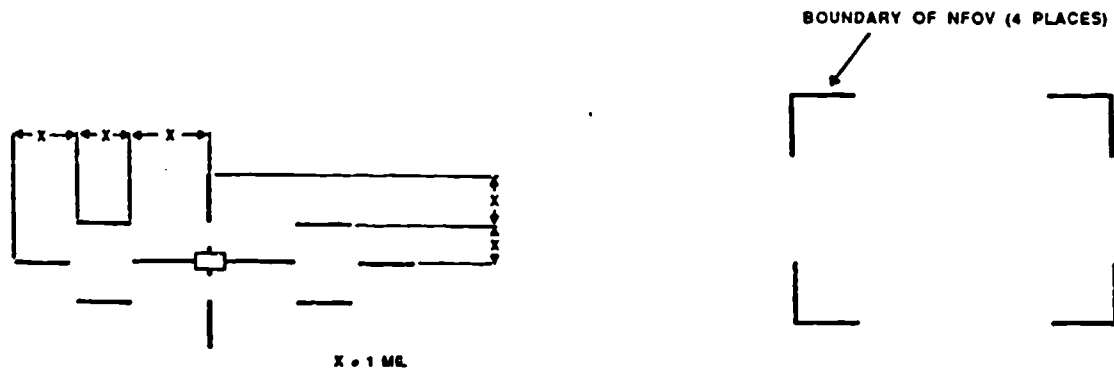


Figure 6. Reticles for narrow field of view (10x) and wide field of view (3x).

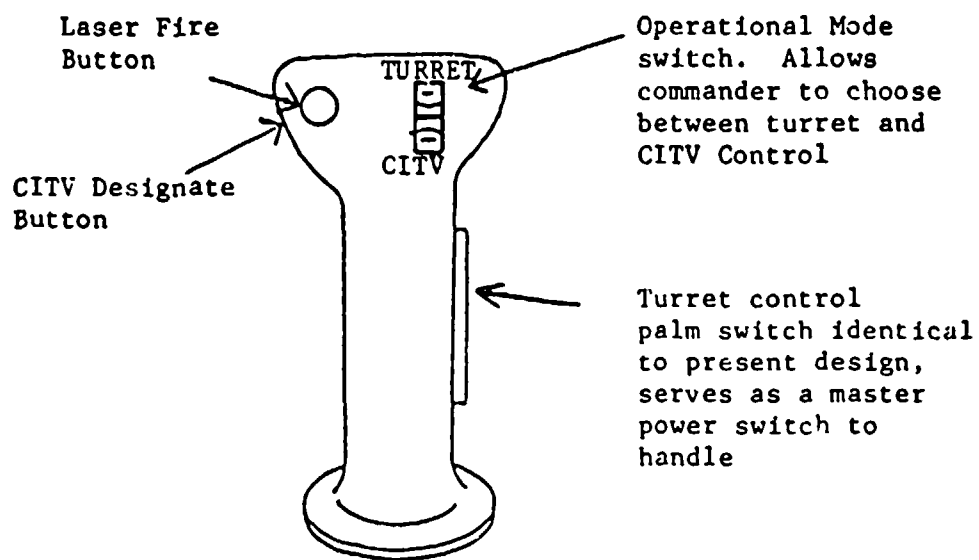


Figure 7. Proposed commander's control handle modified for CITV.

## Research Objectives and Hypotheses

The objective of this research was twofold. This research served first to determine the effectiveness of the CITV as it pertains to individual crew performance. This portion of the effort was conducted to provide Army developers with information related to the operational effectiveness of the system, also referred to as "bang for the buck." While there were data from combat models that showed improvements using the CITV, these data did not include soldier performance in the evaluation of the system. Therefore, the true benefits of the system had not been completely determined. Secondly, the research served to identify potential soldier performance problems associated with the use of the CITV. This portion of the research centered on potential difficulties encountered in the training, indications of poor soldier-machine-interface design, and potential workload issues associated with the use of the CITV.

These objectives were met by examining several hypotheses that were tested in conducting the research effort and also through soldier opinions accumulated from a human factors and training questionnaire. The hypotheses focus on the three major performance measures of speed, accuracy, and quantity; and subjective measures associated with the SMI of the CITV.

Each of these measures was broken down to determine exact soldier behaviors such as detection, acquisition, engagement, and aiming accuracy. The hypotheses to be addressed in this research are as follows:

1. Speed. With the addition of the CITV to the U-COFT, there will be a significant time savings reflected in multiple target engaging when compared to the M1 U-COFT. Specifically, this time savings will be seen in the following measures.

(a) Time spent by the TC and the gunner detecting targets. This reduction in time is due strictly to the addition of the independent sensor and follows the logic that four eyes on the battlefield are better than two.

(b) Time spent in the subsequent engagement of targets. If the hypothesis stated in (a) is true, it logically follows that time to engage subsequent targets would also decrease from that of the current M1.

(c) Range effects on detection and engagement times. This factor will be considered based on the U-COFT work of Witmer (1988), who found that there are significant differences in the U-COFT between speed of opening times that were range dependent (short < 1500 M and long > 1500 M). It is expected, because of this U-COFT finding, that the CITV effects associated with speed will be different at different ranges.

2. Accuracy. Developers expect that the addition of the CITV will lead to increases in accuracy. That is, if detection



time is decreased, more time should be available for gunnery accuracy. The hypothesis regarding gunnery accuracy therefore, is that there will be an increase in gunnery accuracy due to the addition of the CITV.

3. Quantity or number of targets serviced. One of the major advantages linked to the CITV is an increased capability to engage more targets. This advertised capability is based on assumptions related to the increases in speed associated with the CITV. That is, if the TC and gunner can detect, acquire, and engage targets faster, they will be capable of engaging more targets. The hypothesis of this research therefore, is that crews using the CITV will engage significantly more targets than those crews who use the M1 without the CITV.

4. Subjective measures. In addition to the objective measures listed above, subjective information pertaining to soldier-machine interface of the display and controls, ease of use, information loading, workload, and training implications was gathered. This information is exploratory in nature; therefore no hypotheses were proposed.

## Method

### Participants

The participants in the research effort were 40 TC-gunner pairs assigned to various units at Ft Knox. TCs and gunners had served in the Army as tankers an average of 11 years and 8 months and 9 years and 1 month respectively. All were M60A3 or M1 qualified and had previous training on the U-COFT. Biographical data for the participants are summarized in Appendix B.

### Equipment and Materials

The primary equipment for the evaluation consisted of two M1 U-COFTs, both manufactured by General Electric Company. One U-COFT was normally configured, that is, there were no modifications to the current hardware. The CITV U-COFT was configured as explained in the U-COFT/CITV Design paragraph on page 10 of this technical report.

### U-COFT Exercises

A total of 16 CITV exercises were designed to include three factors, own vehicle position (stationary and moving), target position (stationary and moving) and range (short < 1500 M and long > 1500 M). These exercises are shown in Table 1. Eight of these exercises were designated as training exercises and the remaining eight were used for the test. In each exercise 10 targets were spread across four multiple target engagements. Exercises were conducted in day unlimited visibility, and included the following simulated targets: T72 tanks, BMP armored

Table 1

## Factors Considered in the Design of the CITV Exercises

| Number of Exercises | Own Vehicle | Target Vehicle |      | Range |
|---------------------|-------------|----------------|------|-------|
| 2                   | Stationary  | Stationary     | (SS) | Short |
| 2                   | Stationary  | Moving         | (SM) | Short |
| 2                   | Moving      | Stationary     | (MS) | Short |
| 2                   | Moving      | Moving         | (MM) | Short |
| 2                   | Stationary  | Stationary     | (SS) | Long  |
| 2                   | Stationary  | Moving         | (SM) | Long  |
| 2                   | Moving      | Stationary     | (MS) | Long  |
| 2                   | Moving      | Moving         | (MM) | Long  |

personnel carriers, HIND helicopters, and trucks. An example of this exercise composition is shown in Table 2. A complete listing of the exercises is shown in Appendix C. It should be noted that the groups of targets are separated from one another by time intervals, during which no targets are available. The TC however, is unaware of the duration of the intervals because the terrain is still visible. He therefore continues to scan for targets in a vigilant mode.

Only main gun engagements were used during this effort. An own vehicle kill inhibit function was designed into the software to enable data collection from a complete exercise. TCs were not briefed on this function.

#### Procedure

First, each soldier/crew was asked to read a printed copy of the Privacy Act Statement of 1974. Then each crew participated in an orientation and training session designed to (a) explain the purpose of the research and (b) familiarize the crew with the operation of the CITV. This orientation was conducted individually, with one TC-gunner pair per U-COFT at any given time during the training. Participants in the CITV group were given an explanation of the CITV functions and the modifications that had been made to the U-COFT. Preliminary training for the CITV group consisted of verbal instructions presented through the combat vehicle crewman (CVC) helmet. These instructions are

provided in Appendix A. This was followed by hands-on time in the simulator which consisted of structured free-play. Additionally, there was a block of eight training exercises developed specifically to assess crew performance using the CITV known as the "CITV Exercises" (for additional information see Appendix C). These exercises were similar to those used in the actual evaluation. Preliminary training for the No CITV group consisted of the same eight exercises, but without the CITV capability.

Following a rest break after the training, the participants began the evaluation. All participants completed two sessions consisting of four exercises each. These sessions were separated by a 10 minute break to control for the possible effects of fatigue. After the experimental sessions were completed, participants were given a biographical questionnaire (Appendix B) and asked for further subjective information about the CITV through the use of a Human Factors/Training Questionnaire (Appendix F).

Table 2

Sample CITV-Modified U-Go-F Exercise

| Target # | Target | Engagement # |
|----------|--------|--------------|
| 1        | BMP    | 1            |
| 2        | T72    | 1            |
| 3        | HIND   | 2            |
| 4        | TROOPS | 2            |
| 5        | T72    | 2            |
| 6        | TRUCK  | 3            |
| 7        | TRUCK  | 3            |
| 8        | HIND   | 3            |
| 9        | BMP    | 4            |
| 10       | HIND   | 4            |

Note. Engagements consisted of 2, 3, or 4 targets.

Biographical Measures

All participants completed a biographical questionnaire. The biographical measures were: (a) total time in the military,

(b) total time in Armor, (c) total time as a gunner, (d) total time as a TC, and (e) self-reported General Technical (GT) score from the Armed Services Vocational Aptitude Battery. Time in the military was used as a measure of experience and the GT score represented a measure of aptitude. The biographical questionnaire is shown in Appendix B.

### Performance Measures

The main performance measures for this effort were speed, accuracy and quantity. The speed variable was analyzed for two factors: time to engage the first target and subsequent engagement time. The accuracy variable was defined as the gunner's aiming error. This error was calculated using formulae outlined by Biers and Sauer (1982) and is referred to as root mean square (RMS). The quantity variable was analyzed for two items: the percent of available targets detected, and the percent of available targets killed.

### Experimental Design

The experimental design was a 2X2X2X2 repeated measures design with a between subjects comparison for CITV and within subjects comparisons for range, operational status (tank), and target vehicle status (target). The CITV factor is divided into a CITV and a No CITV condition. The range factor is divided into long range and short range. Long range is defined as > 1500 meters and short range is defined as < 1500 meters. These numbers are based on the Witmer (1988) findings pertaining to the range effects on U-COFT performance. The operational status factor is divided into offensive and defensive positions. The offensive status corresponds to own vehicle movement and the defensive corresponds to own vehicle stationary. Target vehicle status is divided into stationary and moving targets (see Table 1).

The design includes a repeated measures analysis for the dependent variables of speed, accuracy, and quantity. The experimental conditions were counterbalanced using a Lattice Squares design (Brownlee, 1957) to prevent order effects often seen in learning and training transfer research.

## Results and Discussion

Statistical analyses were performed on (a) responses to select items from the Biographical Questionnaire, (b) two speed related hypotheses, (c) an accuracy related hypothesis, (d) a quantity related hypothesis, and (e) response to items from the Human Factors/Training Questionnaire.

### Biographical Questionnaire Items

One-way analysis of variance (ANOVA) results, for selected biographical items (GT score and time in service), with group as

a between-subjects factor are reported in Table 3. None of these analyses yielded significant F ratios. These results support the conclusion that the random assignment of crews to the CITV and No CITV groups was successful in equating the groups on these measures. Also any differences between groups that are found to exist on the dependent variables were not attributed to initial differences in mental ability or experience as measured by these items.

Table 3

ANOVA for CITV/No CITV Group and Biographical Items

| Source                 | df   | F    | p level |
|------------------------|------|------|---------|
| TC GT Score            |      |      |         |
| Group                  | 1,38 | .64  | .23     |
| Gunner GT Score        |      |      |         |
| Group                  | 1,38 | .12  | .73     |
| TC Time in Service     |      |      |         |
| Group                  | 1,38 | .00  | .99     |
| Gunner Time in Service |      |      |         |
| Group                  | 1,38 | 1.18 | .28     |

#### Performance Measures

The main performance measures for this effort were speed, accuracy and quantity. The speed variable was analyzed for two factors: time to engage the first target and subsequent engagement time. The accuracy variable was defined as the gunner's aiming error. This error was calculated using formulae outlined by Biers and Sauer (1982)  $RMS = \sqrt{\text{azimuth error}^2 + \text{elevation error}^2}$ . This measure provides an index of the distance in mils from the reticle to the center of target mass at the time of round impact. The quantity variable was analyzed for two items: the percent of available targets detected, and the percent of available targets killed. A summary table of the means and standard deviations for these variables is shown in Table 4.

The multivariate analysis of variance (MANOVA) technique for repeated measures was used (SPSS, 1983). Results are reported in ANOVA tables for explanatory purposes. Tukey's Honestly Significant Difference (HSD) test (see Kirk, 1968, for description) was used on all significant interactions. Pearson correlations were obtained between performance measures and selected biographical items. These correlations are shown in Appendix E.

Table 4

Means and Standard Deviations of Performance Measures With and Without the CITV

| Performance Measure                  | CITV  |      | No CITV |      |
|--------------------------------------|-------|------|---------|------|
|                                      | Mean  | SD   | Mean    | SD   |
| <b>SPEED</b>                         |       |      |         |      |
| First Engagement Time (Seconds)      | 15.73 | 4.2  | 16.89   | 4.5  |
| Subsequent Engagement Time (Seconds) | 39.87 | 5.4  | 43.44   | 3.2  |
| <b>ACCURACY</b>                      |       |      |         |      |
| Root Mean Square (Mils)              | 2.06  | 3.7  | 2.34    | 4.4  |
| <b>QUANTITY</b>                      |       |      |         |      |
| Percent Targets Detected             | 77.68 | 13.8 | 67.12   | 15.2 |
| Percent Targets Killed               | 72.19 | 15.5 | 58.81   | 16.2 |

Speed (1). The speed variable was analyzed for two factors: time to engage the first target (First Engagement Time), and average time to engage a subsequent target (Subsequent Engagement Time). These factors are further defined in the following

statements. First Engagement Time is the time from the exercise start (target fully exposed) to the first target engaged. This is also referred to as the opening time. Average Subsequent Engagement Time is defined as the total engagement time minus time to engage the first target.

The results of the analysis for the First Engagement Time factor are shown in Table 5. The means and standard deviations are provided in Appendix D.

Table 5

ANOVA Summary Table for First Engagement Time

| Source                        | df   | F     | p level |
|-------------------------------|------|-------|---------|
| MAIN EFFECTS:                 |      |       |         |
| Group                         | 1,38 | 1.61  | .21     |
| Range                         |      | 40.68 | .00     |
| Tank                          |      | 14.12 | .00     |
| Target                        |      | 36.37 | .00     |
| INTERACTIONS:                 |      |       |         |
| Group x Range                 | 1,38 | 2.21  | .15     |
| Group x Tank                  |      | .00   | .95     |
| Group x Target                |      | 2.05  | .16     |
| Range x Tank                  |      | .01   | .91     |
| Range x Target                |      | .41   | .53     |
| Tank x Target                 |      | 1.67  | .20     |
| Group x Range x Tank          | 1,38 | 5.02  | .03     |
| Group x Range x Target        |      | 1.59  | .22     |
| Group x Tank x Target         |      | .65   | .43     |
| Range x Tank x Target         |      | 1.58  | .22     |
| Group x Range x Tank x Target | 1,38 | 1.65  | .21     |

As indicated in the Table 5, there was no statistically significant difference between the CITV and No CITV groups ( $F=1.61$ ,  $p>.21$ ). There were, however, significant main effects shown for the range ( $F=40.68$ ,  $p<.00$ ), tank ( $F=14.12$ ,  $p<.00$ ), and target ( $F=36.37$ ,  $p<.00$ ) factors. For the range variable, the analysis indicates that targets located at the longer ranges were associated with longer first engagement times. The time difference associated with the tank variable indicates that tanks in an offensive status took less time to engage the first target.

Finally, it is shown that it takes gunners significantly longer to initially engage moving targets. As shown in Table 5, there were no significant 2-way interactions, however the 3-way Group X Range X Tank interaction did show statistical significance ( $F=5.02$ ,  $p<.03$ ). This interaction was further analyzed using the Tukey HSD test. The results indicated that the interaction is explained by very short times taken by the CITV group to engage short range moving targets and the rather lengthy times taken for the No CITV group to engage long range stationary targets.

These findings, in general, are not unexpected. They show that it takes longer to detect and engage a stationary target, and also targets located at longer ranges. These findings are likely to be attributed to the detection and identification times. The range main effect also supports the Witmer (1988) finding, indicating that there are differences in opening times directly attributed to the range of the target. The data also suggest that large differences exist between the CITV group's engagement times of short range moving targets and the No CITV group's engagement times of long range stationary targets. This finding can be partially attributed to the difficulty one has in locating targets at a far distance using a day sight or the naked eye. This is especially pertinent when the targets are stationary and appear to blend in with the terrain. It could be suggested at this juncture that the CITV user has an edge associated with the FLIR technology, giving him the capability to better differentiate target and terrain at longer distances.

The non-significant group variable finding, however, is in direct opposition with the first speed hypothesis suggesting that with more eyes searching on the battlefield, targets would be detected faster and therefore engaged quicker. The reason why this hypothesis was not supported can be explained by the way the TC-gunner pairs used the CITV system. For example, TCs encouraged their gunners to announce the first target and be ready for a CITV designation to the second target. In choosing this gunner strategy, it seems that they conserved their resources for subsequent target identification and engagement.

Speed (2). The results of the second speed hypothesis, that there would be faster subsequent engagement times for the CITV group, are shown in Table 6. Means and standard deviations are provided in Appendix D.

These results show significant differences between the CITV and No CITV groups ( $F=13.93$ ,  $p<.00$ ), indicating that the CITV group engaged subsequent target faster than the No CITV group. Other significant main effects include: Range ( $F=19.73$ ,  $p<.00$ ) where short range targets were engaged faster, Tank ( $F=23.59$ ,  $p<.00$ ), where tanks in a defensive status engaged targets faster. Targets that were stationary were also engaged faster ( $F=168.05$ ,  $p<.00$ ). These main effects were further explained by the 2-way and higher order interactions. The Group X Target interaction ( $F=11.81$ ,  $p<.00$ ) was analyzed further using the Tukey HSD, indicates that the CITV group engaged subsequent targets faster,



whether stationary or moving. The major difference associated with this significant interaction is attributed to the low engagement times of stationary targets with the CITV versus the high engagement times of moving targets without a CITV.

These findings directly support the hypothesis regarding subsequent engagement times and the efficiency of the CITV. It appears that the TC's strategy to allow the gunner to engage the first target reduced the time needed to complete the engagement. As noted in the data there was ample evidence of the commander acquiring the next target prior to the gunner's completion of the first target engagement. In other words as quickly as the gunner announced the "kill", the commander quickly and very accurately designated the main gun to his own CITV line-of-sight.

Table 6

ANOVA Summary Table for Subsequent Engagement Time

| Source                        | df   | F      | p level |
|-------------------------------|------|--------|---------|
| MAIN EFFECTS:                 |      |        |         |
| Group                         | 1,38 | 13.93  | .00     |
| Range                         |      | 19.73  | .00     |
| Tank                          |      | 23.59  | .00     |
| Target                        |      | 168.05 | .00     |
| INTERACTIONS:                 |      |        |         |
| Group x Range                 | 1,38 | 2.35   | .13     |
| Group x Tank                  |      | 1.01   | .32     |
| Group x Target                |      | 11.81  | .00     |
| Range x Tank                  |      | 1.52   | .23     |
| Range x Target                |      | 5.22   | .03     |
| Tank x Target                 |      | 24.67  | .00     |
| Group x Range x Tank          | 1,38 | .04    | .84     |
| Group x Range x Target        |      | 7.37   | .01     |
| Group x Tank x Target         |      | 2.75   | .11     |
| Range x Tank x Target         |      | 9.12   | .01     |
| Group x Range x Tank x Target | 1,38 | .11    | .74     |

This target engagement procedure is completely new for the crews. It requires a major change in the way TCs fight their tank. Therefore, it is suggested that these differences, while significant, will become even greater as the hand-off procedures

are better identified by U.S. Army trainers and tank crews become more proficient in the use of the CITV.

Accuracy. The results of the accuracy hypothesis, there would be more accurate gunnery for the CITV group, are shown in Table 7. Means and standard deviations are provided in Appendix D.

Table 7

ANOVA Summary Table for Target Accuracy (Root Mean Square)

| Source                        | df   | F    | p level |
|-------------------------------|------|------|---------|
| MAIN EFFECTS:                 |      |      |         |
| Group                         | 1,38 | .07  | .79     |
| Range                         |      | .01  | .92     |
| Tank                          |      | 1.81 | .19     |
| Target                        |      | 3.56 | .07     |
| INTERACTIONS:                 |      |      |         |
| Group x Range                 | 1,38 | 3.88 | .06     |
| Group x Tank                  |      | .00  | .98     |
| Group x Target                |      | .01  | .91     |
| Range x Tank                  |      | .07  | .80     |
| Range x Target                |      | .06  | .80     |
| Tank x Target                 |      | 6.21 | .02     |
| Group x Range x Tank          | 1,38 | 3.54 | .07     |
| Group x Range x Target        |      | 3.44 | .07     |
| Group x Tank x Target         |      | .03  | .86     |
| Range x Tank x Target         |      | .00  | .99     |
| Group x Range x Tank x Target | 1,38 | 4.05 | .05     |

As indicated in Table 7, there were no significant main effects associated with the accuracy variable. There was, however, a significant Group X Range interaction. This interaction was further analyzed using the Tukey HSD, indicate that gunners in the CITV group were more accurate when firing at short range targets whereas the gunners in the No CITV group were more accurate when firing at long range targets. There was also a significant higher order interaction, Group X Range X Tank X Target. The results of the Tukey HSD indicated that the major contribution of the significance could be attributed to the difference between the accuracy of the CITV and No CITV groups in

a defensive engagement where targets are moving. The data indicate that the CITV gunners were more accurate at short range while the No CITV gunners were more accurate at long range. There is no immediate explanation for these significant interactions.

It appears that the gunner accuracy is not affected by the inclusion of the CITV. This finding can likely be attributed to current gunnery training methods and the training provided for the CITV evaluation. That is, speed was emphasized many times whereas accuracy remained a given. This creates a speed accuracy tradeoff situation for the gunner. When the gunner faces such a tradeoff decision, he is more likely to revert to previous training that emphasizes the speed aspect.

Quantity(1). The results of the first quantity hypothesis, that more targets would be detected by the CITV group, are shown in Table 8. Means and standard deviations are provided in Appendix D.

Table 8

ANOVA Summary Table for Percent of Targets Detected

| Source                        | df   | F     | p level |
|-------------------------------|------|-------|---------|
| MAIN EFFECTS:                 |      |       |         |
| Group                         | 1,38 | 2.32  | .00     |
| Range                         |      | 93.53 | .00     |
| Tank                          |      | 97.93 | .00     |
| Target                        |      | 27.46 | .00     |
| INTERACTIONS:                 |      |       |         |
| Group x Range                 | 1,38 | .08   | .83     |
| Group x Tank                  |      | .11   | .74     |
| Group x Target                |      | .00   | .96     |
| Range x Tank                  |      | .00   | .96     |
| Range x Target                |      | 23.74 | .00     |
| Tank x Target                 |      | .02   | .89     |
| Group x Range x Tank          | 1,38 | .21   | .65     |
| Group x Range x Target        |      | .95   | .34     |
| Group x Tank x Target         |      | .05   | .82     |
| Range x Tank x Target         |      | 16.81 | .00     |
| Group x Range x Tank x Target | 1,38 | .16   | .69     |

As shown in Table 8, the results indicate significant differences between the CITV and No CITV groups ( $F=2.32$ ,  $p<.00$ ) in the percentage of total number of targets detected. The data show that the CITV group detected approximately 11% more targets than did the No CITV group. There were also other significant main effects. These include the Range variable ( $F=93.53$ ,  $p<.00$ ), the Tank variable ( $F=97.93$ ,  $p<.00$ ), and the Target variable ( $F=27.46$ ,  $p<.00$ ).

The analysis for the Range variable indicates that crews overall detected more short-range than long-range targets. This difference equated to approximately 10%. These data show further support for the Witmer (1988) finding of the range differential in the U-COFT.

The analysis for the Tank variable indicates that crews in the defensive status detected approximately 17% more targets than those in an offensive status. This finding certainly is supported by the vigilance and selective attention literature. That is, in a defensive status, the crew is set, cognizant of a probable attack, and focuses their attention to their sector of responsibility. This heightened state of readiness increases the probability of target detection. In an offensive status, the crew still has a sector of responsibility; however, the uncertainty associated with the moving mission disperses the focus of their attention. This dispersion decreases the probability of detection.

The analysis for the Target variable indicates that crews detected approximately 7% more stationary targets than moving targets. This finding is slightly perplexing, as the vigilance and sensory literature would suggest that movement should be an overriding cue for detection, especially at long ranges. However, one could postulate that the CITV technology (e.g., FLIR) compensates for some of the deficiencies of the human eye and allows the crew members to detect a target that was previously undetectable.

The data support the hypothesis that the CITV group would be able to detect more targets. These findings follow the same logic that two sets of eyes independently scanning the battlefield will have a greater probability of detecting more targets. The data however, do little to provide more information to the Army about where the advantage of the CITV really lies. Early combat model work placed the payoff of the CITV in the offensive posture, still other work indicated that the payoff of the CITV would be in the long-range detection. The result of the analyses for this research, unfortunately, cannot support either of these findings.

Quantity (2). The results of the second quantity hypothesis, that more targets would be killed by the CITV group, are shown in Table 9. Means and standard deviations are provided in Appendix D.

As shown in Table 9, the results indicate a significant difference between the CITV and No CITV groups ( $F=12.91$ ,  $p<.00$ ) in the percentage of total number of targets killed. The data show that the CITV group killed approximately 14% more targets than did the No CITV group. There were also other significant main effects. These include the Range variable ( $F=124.05$ ,  $p<.00$ ), the Tank variable ( $F=115.89$ ,  $p<.00$ ), and the Target variable ( $F=27.18$ ,  $p<.00$ ).

Table 9

ANOVA Summary Table for Percent of Targets Killed

| Source                        | df   | F      | p level |
|-------------------------------|------|--------|---------|
| MAIN EFFECTS:                 |      |        |         |
| Group                         | 1,38 | 18.14  | .00     |
| Range                         |      | 124.05 | .00     |
| Tank                          |      | 115.89 | .00     |
| Target                        |      | 27.18  | .00     |
| INTERACTIONS:                 |      |        |         |
| Group x Range                 | 1,38 | 2.49   | .12     |
| Group x Tank                  |      | 5.25   | .03     |
| Group x Target                |      | 13.32  | .00     |
| Range x Tank                  |      | .60    | .44     |
| Range x Target                |      | 12.72  | .00     |
| Tank x Target                 |      | 15.95  | .00     |
| Group x Range x Tank          | 1,38 | 1.76   | .19     |
| Group x Range x Target        |      | 2.87   | .10     |
| Group x Tank x Target         |      | .88    | .35     |
| Range x Tank x Target         |      | 38.05  | .00     |
| Group x Range x Tank x Target |      | 6.27   | .02     |

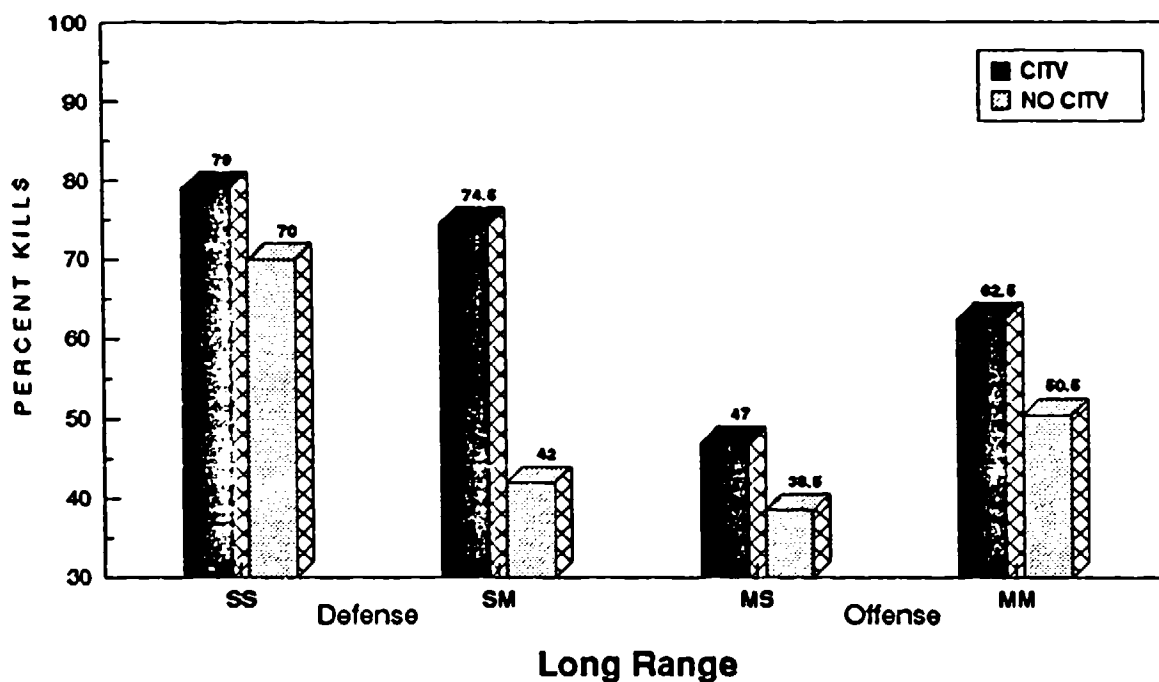
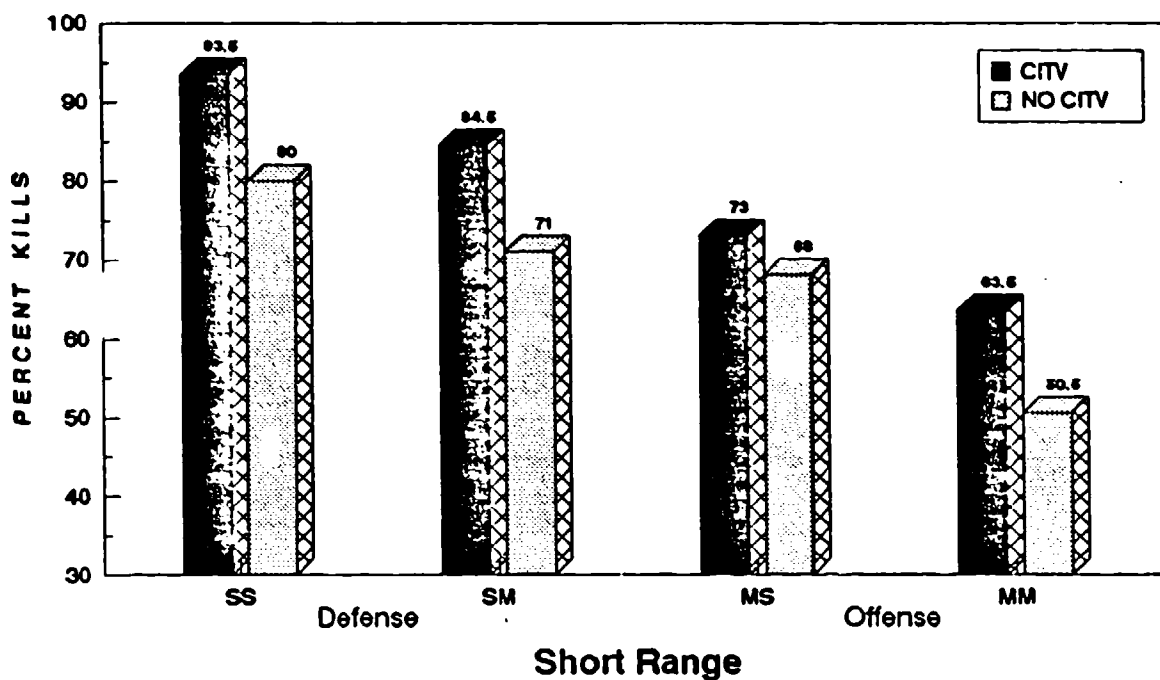
The analysis for the Range variable indicates that tank crews overall killed more short range than long range targets. This difference equated to approximately 15%. These data are not unexpected especially given the detection findings earlier that indicate more targets located at short ranges were detected. The analysis for the Tank variable indicates that crews in the defensive status killed approximately 18% more targets than those in an offensive status. Again this finding should be expected, given the detection differences noted above. The analysis for the Target variable indicates that crews kill approximately 6% more

stationary targets than moving targets. Unlike the perplexity that was noted for the detection finding, the finding that crews kill more stationary than moving targets is expected. That is, it is easier to kill a stationary target as there is no tracking requirement.

The data support the hypothesis that the CITV group would be able to kill more targets. These findings, like the detection findings, follow the logic that two sets of eyes independently scanning the battlefield will have a greater probability of detecting more targets. Additionally, with the target designate function the TC can get the gunner onto more targets for subsequent kills. The kill data do provide more information about the advantages of the CITV.

The significant 2-way interactions of Group X Tank ( $F=5.25$ ,  $p<.03$ ), and Group X Target ( $F=13.32$ ,  $p<.00$ ) were further analyzed using the Tukey HSD. A similar analysis was conducted for the significant higher order Group X Range X Tank X Target interaction ( $F=6.27$ ,  $p<.02$ ). The results of the analysis on the Group X Tank interaction indicate the advantage of the CITV in the defensive status. There is an obvious difference within the CITV group alone that equates to an approximately 20% difference in the number of targets killed. The major contributor to the significance of the interaction, however, is the approximately 30% difference found between the CITV group's defensive kills and the No CITV group's offensive kills. The analysis of the Group X Target interaction indicates that there is a relatively small difference within the CITV user group as it pertains to stationary and moving targets. That is, there is only a 2% difference in favor of the stationary target kills. The major contributor to the significance is the approximately 20% difference between the CITV group's stationary kills and the No CITV moving kills. It is also noted that there was a difference of approximately 18% between the CITV group's moving kills and the No CITV moving kills. The most enlightening information about the advantage of the CITV is presented in the depiction of the Group X Range X Tank X Target interaction, shown in Figure 8. While there are several significant findings illustrated in this figure, the most obvious difference lies in the CITV advantage reflected in the defensive status with long range moving targets.

These findings directly support the hypothesis regarding efficiency of the CITV as indicated by the number of kills. The differences between the CITV and No CITV are more clearly explained in the higher order interactions. Those interactions indicate that there are a number of payoffs for a crew using the CITV. These CITV payoffs include the own tank status, where the CITV group killed the most targets when in the defense position. However it should also be noted that the CITV group also outkilled in the offensive position, but at a lower percentage rate. The status of the targets also appears to be an important factor. The main effect analysis for Target indicated a slight increase in the number of stationary targets, however when this



SS-Stationary Tank vs. Stationary Target  
 SM-Stationary Tank vs. Moving Target  
 MS-Moving Tank vs. Stationary Target  
 MM-Moving Tank vs. Moving Target

Figure 8. Group x Range x Tank x Target Interaction for Percent Kills.

variable was analyzed with the others it appears as a focal point. The largest difference between the groups is in the defensive position where long range targets are moving. Perhaps more than any, this example supports the basic CITV logic.

Subjective Responses. The results of the Human Factors/ Training Questionnaire are shown in Appendix F. These results plus unstructured interviews are the basis for this section on subjective responses. Overall, the soldier responses indicate a favorable attitude toward the inclusion of the CITV. Seventy five percent of the commanders felt that the CITV would assist them in their job. They listed the major advantage (50%) as target acquisition and detection, while 20% saw the designation capability as the primary advantage.

The information gathered on workload and/or information loading associated with the system follows. Ninety-five percent of the TCs indicated that the information level of the CITV was manageable. However, at least 50% of the commanders indicated that the orientation icon that tells the TC where his CITV is in relation to the hull and main gun, could be much improved by making it a directional indicator rather than the relational indicator it is now. This was especially true for the offensive status. Generally, commanders agreed that the new workload associated with the CITV was minimal. However, they also suggested that when the CITV was put into a tank with complete vision blocks, the workload would increase due to the coordination between the gunner's primary sight extension (GPSE), the CITV, and the vision blocks. This concern was better stated by 20% of the commanders when they acknowledged that they did not get lost in U-COFT, but that they probably would in the field.

There were several responses that pertain to system design or redesign. Seventy-five percent of the soldiers suggested the need to redesign the current control handle. This concern centered around the need to engage a palm switch and use the designate switch that was located on the top left of the handle. Many commanders released the palm switch when trying to reach the designate button. When this occurred the slew of the main gun was not completed. The suggested solution to this design issue was to move the palm switch to the front for finger control and less reach. It should be noted that this solution also facilitates a transfer of motor learning from the gunner's position. His controls currently have front finger switches that allow responses such as target tracking.

Twenty percent of the commanders indicated that the magnification switch located on the CITV casing should be moved to a more accessible place. The rationale for this move was the frequency of use associated with this switch. The location on the casing caused excessive movement and breaks in attention.

Gunners also voiced a need for some type of CITV information for the gunner's sight. The rationale for this information centers on the commander designating a gunner to an area unknown



to the gunner. It was felt that if the gunner was to be given a command to return to his original sector of responsibility, he would not know where he was located. An icon, located in the gunner's sight would greatly assist him in his tank.

With respect to training, the majority of the commanders indicated a need for the coordinated training of the gunner and commander. It was suggested that without this change in training procedure the CITV could not reach a maximum payoff. At least 80% of the soldiers suggested using abbreviated fire commands. They felt that they could now get to targets quicker and therefore, did not need long commands that slowed down the process. There was also some concern expressed for more information about the tactics, techniques, and procedures with the addition of the CITV. For example, how and when would TCs in various positions (platoon leader vs platoon sergeant vs wingmen) would utilize the system.

### Summary

The research achieved both of the designated purposes. First, it was proposed to provide information pertaining to the operational effectiveness of the system. Second, it was proposed to point out design flaws and identify potential problematic issues associated with the training of the system.

For the operational effectiveness portion of the research, the worth of the CITV was clearly demonstrated. Early combat models predicted system performance; however, there was no information about the soldier's performance that would allow developers the information about the real performance of the system (soldier + machine). This research provides information which reflects system speed, accuracy, and quantity. The results indicate the CITV decreases the time to engage multiple targets. These results indicate that the payoff of the CITV is not captured until the second or third target is engaged. That is, the results indicated that there was no difference between the CITV and No CITV groups in the time to engage the first target. It is suggested that this finding is due to the commander's strategy to maximize the use of the CITV emphasizing multiple kills rather than first kill. The time payoff, as emphasized in the subjective responses area is a result the crews' coordination and experience with the system. It is therefore appropriate to note here that the time payoff reported in this research is lower than those of combat models. While it is questionable that soldier-in-the-loop information would achieve the levels predicted by the combat models, one would certainly expect that the times provided herein would decrease as experience and coordinated crew practice increased.

The measure that was chosen to evaluate the accuracy dimension of operations with the CITV failed to show any significant differences between the CITV and No CITV groups. The original hypothesis suggested that the expected decrease in time

taken to find new targets would allow gunners to become more accurate in their gunnery. It appears that in this research effort the crew was placed in a tradeoff position that involves speedy or accurate actions. The gunners appear to have chosen the speed. While this finding was perhaps discouraging it does highlight a problematic area for the training expert who will design the program for the CITV.

The findings associated with the quantity measures once again indicated the worth of the CITV. Crews detected significantly more of the available targets in the CITV condition, and they also were able to kill more of the targets. Of interest here were the interactions that indicated potential payoff areas for the CITV. In general it was found that CITV groups were able to kill more targets in both the offense and defense. However, it was shown that the largest payoff in this evaluation was in a defensive setting where long range moving targets were present. It would appear that more research is necessary, especially if experts charged with the advanced tactical use of this equipment are to provide the trainers with the appropriate information to make best use of the system.

The subjective responses by TCs pertaining to training indicate:

- Increased crew training will be necessary to allow fast and accurate target hand off.
- More information about tactic, techniques, procedures (TTPs) is imperative. This includes how and when to utilize the system. Additionally, it was noted that TCs in different positions (platoon leader, platoon sergeant, wingmen) might use the CITV in different ways.
- New abbreviated fire control commands are necessary in order to realize the increase in the speed associated with the CITV.
- Modifications to the current U-COFT performance measuring system are necessary to account for the independent actions of the TCs.
- New U-COFT scenarios are necessary to fully train the use of the CITV. Also it is suggested that more research be conducted to allow tactical analysts to determine appropriate sectors of search with the addition of the CITV.
- Modifications to existing gunnery ranges are needed to allow for full utilization of the CITV without safety constraints.

The subjective responses pertaining to the soldier-machine-interface include:

- The design of a new commander's control handle to facilitate easy control of the CITV should be considered.
- The design of the TC's orientation icon should consider the inclusion of a moving hull to represent directional movement of the tank.
- The inclusion of an icon for the gunner to allow him to be more cognizant of his sector placement after being designated by the TC to the CITV line-of-sight would be helpful.
- The magnification switch should be relocated for easier activation.
- The operational mode switch should be relocated to prevent accidental activation.

The research effort described herein is unique in that it attempted to modify an existing training device to address soldier performance in the early stages of the acquisition of the system. Subsequently, information was provided to combat and training developers relatively early in the design phases of the system. This allowed developers and other agencies to (a) examine the operational effectiveness of the CITV with the soldier in the loop, (b) identify problematic design flaws, and (c) identify potential problematic areas associated with the training of the system. Moreover, the results of this research led to subsequent testing by the Human Engineering Laboratory (HEL) on a new commander's control handle, research on alternative configurations of the TC's orientation icon, and research on tactics, technique, and procedures at platoon level.

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## APPENDIX A

### Instructions to Participants

#### CITV Instructions

The purpose of this training tape is to familiarize M1 commander/gunner teams with the use of the CITV. Let's discuss the CITV switches and controls.

First, the operational or ON/OFF/STANDBY switch.

When the CITV operational switch is in the OFF position the system is nonfunctional. When the CITV is set to the Standby position - after approximately 10 seconds a flashing green light located on the panel will illuminate to indicate ready. The ON switch: When the ON switch is selected all of the CITV's power will come on and the CITV will automatically align with the main weapon, that is Gun Line of Sight.

Next let's discuss the switches that allow the CITV to automatically scan.

Sector Set: The SECTOR SET switch, located on the left side of the control panel allows you to set the left and right limits of the area to be scanned by the CITV when using auto scan.

Rate Set: The RATE SET allows you to set a comfortable rate of CITV scanning between the left and right limits when using auto scan.

Increase/Yes and Decrease/No: These switches, when used with other function switches, allow you to adjust the CITV. For example your preference for the rate of scan, brightness of the reticle and symbol, and the contrast and sensitivity can be adjusted using the INCREASE and DECREASE switches.

Other switches include:

The POLARITY switch, which allows you to choose WHITEHOT or BLACKHOT viewing of the CITV display and the MAGNIFICATION switch that is used to select three power or ten power magnification of the CITV image.

So far we have discussed two operational modes, Gun Line Of Sight and Auto Scan. There is a third operational mode called Manual Search. Manual search provides the commander the capability of using the commander's control handle to manually search for targets with the CITV. This is a very important function, as it allows the commander to interrupt the auto scan for a closer look at a suspected target. It also allows the commander to control the movement of the CITV strictly at his command. This operational mode can be entered in two ways. The first is to

simply push the MANUAL SEARCH switch located on the bottom of the control panel. The second is through the grasping of the commander's control handle. That is, anytime the commander is using the CITV and he grasps the control handle, he will be in Manual Search mode and the light on the panel will be illuminated.

There are other CITV related controls that are not located on the control panel. These include:

The Orientation indicator that gives the commander a visual reference of the relationship of the CITV, the turret and hull positions.

The PALM switch on the commander's control handle that provides power to the commander's handle when depressed, also allows the CITV to function properly.

The OPERATIONAL MODE rocker switch that is located on top of the commander's control handle provides the commander with the capability to control the turret when in TURRET MODE (switch pushed to the forward position) or control the CITV when the CITV mode is selected (switch pushed to the rear position).

The LASER FIRE and CITV DESIGNATE button that is located on the commander's control handle. When the OPERATIONAL MODE switch is set to control the turret the laser is functional. Therefore, if you push the LASER FIRE button it will operate as it does in the current tank. However, when the OPERATIONAL MODE switch is set to CITV the button becomes a TARGET DESIGNATE control. That is, if you push this button while in CITV mode you will slew the main gun and the reticle to the exact spot where your CITV is aimed.

Now that you are familiar with the CITV switches and controls, let's discuss the procedures for operating the CITV. This is not a difficult task as you shall soon see.

Located on the top right of your control panel is a two position switch labeled CONTRAST - SENSITIVITY. Press once and CONTRAST will illuminate along with your INCREASE and DECREASE switches that are located on the bottom right of the panel. The INCREASE and DECREASE switches can be used to adjust your contrast. Press the CONTRAST SENSITIVITY switch for the second time and SENSITIVITY will be illuminated. Again, you can use your INCREASE and DECREASE switches to adjust your sensitivity setting. Press the CONTRAST - SENSITIVITY switch for the third time and the switch will go off.

The POLARITY switch located on the right side of the control panel is used to select WHITEHOT or BLACKHOT viewing. Press the switch once and WHITEHOT will be illuminated and

the CITV image will appear as WHITEHOT. Press the switch again and BLACKHOT will be illuminated and the CITV image will change to appear as BLACKHOT.

The BRIGHTNESS switch for your reticle and your symbols is located on the top left of your control panel. Press this switch once and RETICLE and the INCREASE and DECREASE switches will illuminate. This switch is used to adjust your reticle brightness using the INCREASE and DECREASE switches. If you press this switch for the second time SYMBOL and INCREASE and DECREASE will illuminate. Using the INCREASE and DECREASE switches you can adjust the brightness of the symbol. Press this switch for the third time and it will go off.

The mode switches: GUN LINE OF SIGHT, AUTO SCAN, and MANUAL SEARCH are located center bottom of your control panel.

At this time we will discuss AUTO SCAN. Press AUTO SCAN once, and the SECTOR SET switch will illuminate. Press your SECTOR SET switch once, and ensure that your CITV switch is set in CITV mode. Grasp your commander's control handle, traverse left to the outer limit of the desired sector. Then press SECTOR SET again. This action sets your left sector limit. Grasp the commander's control handle again and traverse right to the outer limit of the desired sector. Once your right and left limits are set, press SECTOR SET again. This action sets your right sector and will allow the CITV to automatically scan the established sector.

At this point you must establish the rate at which you would like the CITV to scan. To do this push the RATE SET switch and grasp the commander's control handle. Then traverse the handle from the right sector limit back to your left sector limit at the rate you desire. Then press the RATE SET switch a second time and the CITV will begin to automatically scan. Note here that if at any time during the use of the CITV you want to change the scanning rate, you simply push the RATE SET switch. This action will illuminate the RATE SET and the INCREASE and DECREASE switches. Use the INCREASE and DECREASE switches to reset the rate of CITV scanning speed. Once you have the desired rate, press RATE SET and it will go off, maintaining the rate that you have set.

Next, let's discuss the use of the GUN LINE OF SIGHT and MANUAL SEARCH switches.

Pressing the GUN LINE OF SIGHT switch causes the CITV to automatically slew to align with the main gun. That is, the CITV screen should display the same image as in the Gunner Primary Sight. Pressing the MANUAL SEARCH switch enables the tank commander to manually search the targets using his commander's control handle. If



you need to change magnification during this search the magnification switch is located on the bottom right of the panel. You can select either three power or ten power.

On the commander's handle is located the OPERATIONAL MODE switch.

This OPERATIONAL MODE switch when moved to the rear and in the CITV mode functions as an override as it were to traverse the CITV manually. When placed in the forward or turret position the override or commander's handle functions as a normal override to include the trigger and the LASE button. When the CITV or OPERATIONAL MODE switch is moved to the rear, the LASE button becomes a target designate button. Pressing this button with the OPERATIONAL MODE switch in the CITV position will cause the main gun to slew and align where the CITV is aligned at. If you have any questions concerning the CITV at this time please ask your instructor operator.

Now, let's discuss the TC and gunner's actions during a main gun engagement with multiple targets.

Regardless of the target array, the TC will begin engagement with a precision fire command such as "Gunner, Sabot, Tank". Once an ID has been given by the gunner, the tank commander will say "Fire" and "Adjust". Ensuring that the CITV OPERATIONAL MODE switch is in the rear or the CITV position, the tank commander will then slew the CITV and align it on the next target. Once the gunner has given his observation of target, the tank commander will designate and cause the main gun to slew and align with the CITV. At this time, the tank commander will give a target description in the shortest time possible. Such as, Tank PC or Chopper. When the gunner has given an ID, the tank commander will then say "Fire" and "Adjust", slewing the CITV to the next target.

This sequence will be repeated in a multiple main gun engagement until all targets have been destroyed.

The tank commander will then end the engagement with a standard command of "cease fire" and then take appropriate actions for placement of his vehicle back in the defensive turret down position with battle carry sabot ready for the next engagement.

The crew should also be aware of the field of view of the CITV that is 270 degrees. The CITV can be rotated 360 degrees, but when it is rotated by the doghouse and the commander's cupola, the screen will appear green. Also, due to this particular test and this model of CITV there is no obscuration due to main gun fire.

At this time if you have any questions refer to your instructor operator.

APPENDIX B

Biographical Questionnaire

Subject # \_\_\_\_\_ Group \_\_\_\_\_ Date \_\_\_\_\_

1. Age \_\_\_\_\_ years
2. Grade E-\_\_\_\_\_
3. Education level. Circle one.
  - a. Less than 12 years
  - b. GED
  - c. High School Graduate
  - d. Vocational School
  - e. Some College \_\_\_\_\_ years
  - f. College Graduate
  - g. Other (describe briefly) \_\_\_\_\_
4. General Technical (GT) score \_\_\_\_\_ Social Security No. \_\_\_\_\_
5. Total time in service \_\_\_\_\_ years \_\_\_\_\_ mos.
6. How long have you been in an Armor MOS? \_\_\_\_\_ years \_\_\_\_\_ mos.
7. Present crew position \_\_\_\_\_ mos. Time in that position \_\_\_\_\_ mos. Present vehicle \_\_\_\_\_ mos.
8. Total time as a Tank Commander \_\_\_\_\_ mos. Time as M1 TC \_\_\_\_\_ mos. Time as M60A3 TC \_\_\_\_\_ mos.
9. Total time as a gunner \_\_\_\_\_ mos. Time as M1 gunner \_\_\_\_\_ mos. Time as M60A3 gunner \_\_\_\_\_ mos. Other gunnery time \_\_\_\_\_ mos. Vehicle \_\_\_\_\_
10. Not counting COFT when was your last training/sustainment gunnery practice? \_\_\_\_\_ mos. ago.
11. On how many separate occasions have you fired the COFT? \_\_\_\_\_

Summary of Selected Biographical Data

Group Tank Commander

1. Average age 32.4 years
2. Grade E-4 00 E-5 03 E-6 20 E-7 16 E-8 01
3. Education level.  
01 Less than 12 years 08 GED 12 High School Graduate  
02 Vocational School 14 Some College  
03 College Graduate
4. Average General Technical (GT) score 114
5. Average time in an Armor MOS? 11 years 08 months
6. Average time as a Tank Commander 04 years 08 months

Summary of Selected Biographical Data

Group Gunner

1. Average age 22 years
2. Grade E-4 02 E-5 18 E-6 14 E-7 09 E-8 00
3. Education level.  
00 Less than 12 years 06 GED 24 High School Graduate  
00 Vocational School 07 Some College  
03 College Graduate
4. Average General Technical (GT) score 107
5. Average time in an Armor MOS? 09 years 01 months
6. Average time as a Gunner 02 years 01 months

## APPENDIX C

### U-COFT Test Exercises

Test Exercise 932110

Short Range, Stationary Own Vehicle, Stationary Target

#### 1. SCOPE

The crew, occupying a stationary firing position, engages multiple stationary targets located from 900-1350 meters. Visibility is day unlimited and the tank is fully operational. CITV is available.

#### 2. EXERCISE SUMMARY

| <u>Situation</u>      | <u>Type</u> | <u>Range</u> | <u>Motion</u> | <u>Orientation</u> |
|-----------------------|-------------|--------------|---------------|--------------------|
| 1                     | Tank        | 1100         | Stationary    | 45 Left            |
|                       | BMP         | 1100         | Stationary    | Full Left          |
|                       | Helicopter  | 1250         | Stationary    | Full Right         |
| -- 30 second interval |             |              |               |                    |
| 2                     | Tank        | 900          | Stationary    | Front              |
|                       | Tank        | 1310         | Stationary    | 45 Right           |
| -- 60 second interval |             |              |               |                    |
| 3                     | Truck       | 1320         | Stationary    | 45 Right           |
|                       | Truck       | 1230         | Stationary    | 45 Right           |
| -- 30 second interval |             |              |               |                    |
| 4                     | Helicopter  | 1350         | Stationary    | Front              |
|                       | Tank        | 800          | Stationary    | 45 Right           |
|                       | Helicopter  | 1350         | Stationary    | 45 Left            |

Test Exercise 934110  
Short Range, Stationary Own Vehicle, Moving Target

1. SCOPE

The crew, occupying a stationary firing position, engages multiple moving targets located from 930-1440 meters. Visibility is day unlimited and the tank is fully operational. CITV is available.

2. EXERCISE SUMMARY

| <u>Situation</u>      | <u>Type</u> | <u>Range</u> | <u>Tgt Velocity</u> | <u>Orientation</u> |
|-----------------------|-------------|--------------|---------------------|--------------------|
| 1                     | BMP         | 1310         | 15 MPH              | Full Left          |
|                       | Tank        | 1430         | 19 MPH              | Full Left          |
| -- 30 second interval |             |              |                     |                    |
| 2                     | Tank        | 1340         | 16 MPH              | Front              |
|                       | BMP         | 940          | 17 MPH              | Full Right         |
|                       | Tank        | 960          | 16 MPH              | Full Right         |
| -- 60 second interval |             |              |                     |                    |
| 3                     | Tank        | 1110         | 16 MPH              | Full Left          |
|                       | Helicopter  | 1400         | 16 MPH              | 45 Right           |
|                       | Tank        | 1440         | 15 MPH              | Front              |
| -- 30 second interval |             |              |                     |                    |
| 4                     | Tank        | 1350         | 14 MPH              | 45 Right           |
|                       | BMP         | 930          | 14 MPH              | Full Right         |

Test Exercise 935110  
Short Range, Moving Own Vehicle, Moving Target

1. SCOPE

The crew, operating a moving tank, engages multiple moving targets located from 700-1400 meters. Visibility is day unlimited and the tank is fully operational. CITV is available.

2. EXERCISE SUMMARY

| <u>Situation</u>      | <u>Type</u> | <u>Range</u> | <u>Tgt Velocity</u> | <u>Orientation</u> |
|-----------------------|-------------|--------------|---------------------|--------------------|
| 1                     | Tank        | 1700         | 18 MPH              | 45 Left            |
|                       | Tank        | 1410         | 12 MPH              | 45 Left            |
| -- 30 second interval |             |              |                     |                    |
| 2                     | Tank        | 1170         | 12 MPH              | Full Right         |
|                       | BMP         | 1410         | 12 MPH              | Full Left          |
|                       | Tank        | 1170         | 16 MPH              | 45 Left            |
| -- 60 second interval |             |              |                     |                    |
| 3                     | Helicopter  | 1290         | 21 MPH              | 45 Right           |
|                       | Tank        | 1300         | 10 MPH              | 45 Left            |
| -- 30 second interval |             |              |                     |                    |
| 4                     | Tank        | 1320         | 10 MPH              | Full Left          |
|                       | Tank        | 1130         | 16 MPH              | 45 Right           |
|                       | BMP         | 810          | 13 MPH              | 45 Left            |



Test Exercise 933110

Short Range, Moving Own Vehicle, Stationary Target

1. SCOPE

The crew, operating a moving tank, engages multiple moving targets located from 490-1450 meters. Visibility is day unlimited and the tank is fully operational. CITV is available.

2. EXERCISE SUMMARY

| <u>Situation</u>      | <u>Type</u> | <u>Range</u> | <u>Motion</u> | <u>Orientation</u> |
|-----------------------|-------------|--------------|---------------|--------------------|
| 1                     | Tank        | 1120         | Stationary    | 45 Left            |
|                       | BMP         | 1270         | Stationary    | 45 Right           |
|                       | Tank        | 1450         | Stationary    | Full Right         |
| -- 30 second interval |             |              |               |                    |
| 2                     | Helicopter  | 1290         | Stationary    | Full Left          |
|                       | Tank        | 910          | Stationary    | Full Right         |
| -- 60 second interval |             |              |               |                    |
| 3                     | Troops      | 490          | Stationary    | Front              |
|                       | Tank        | 1010         | Stationary    | Full Right         |
| -- 30 second interval |             |              |               |                    |
| 4                     | Helicopter  | 1280         | Stationary    | Full Right         |
|                       | Tank        | 1000         | Stationary    | Full Right         |
|                       | Helicopter  | 1160         | Stationary    | 45 Left            |

Test Exercise 942210  
Long Range, Stationary Own Vehicle, Stationary Target

1. SCOPE

The crew, occupying a stationary firing position, engages multiple stationary targets located from 1530-2140 meters. Visibility is day unlimited and the tank is fully operational. CITV is available.

2. EXERCISE SUMMARY

| <u>Situation</u>      | <u>Type</u> | <u>Range</u> | <u>Motion</u> | <u>Orientation</u> |
|-----------------------|-------------|--------------|---------------|--------------------|
| 1                     | Tank        | 1720         | Stationary    | 45 Right           |
|                       | BMP         | 1910         | Stationary    | Full Right         |
| -- 30 second interval |             |              |               |                    |
| 2                     | Helicopter  | 2080         | Stationary    | Full Right         |
|                       | Truck       | 1570         | Stationary    | 45 Right           |
|                       | Tank        | 1620         | Stationary    | 45 Left            |
|                       | Tank        | 2070         | Stationary    | Full Left          |
| -- 60 second interval |             |              |               |                    |
| 3                     | Tank        | 2070         | Stationary    | 45 Left            |
|                       | Helicopter  | 2140         | Stationary    | Full Right         |
| -- 30 second interval |             |              |               |                    |
| 4                     | Helicopter  | 2110         | Stationary    | 45 Right           |
|                       | Truck       | 1530         | Stationary    | Full Right         |

Test Exercise 944110  
Long Range, Stationary Own Vehicle, Moving Target

1. SCOPE

The crew, occupying a stationary firing position, engages multiple moving targets located from 1590-2060 meters. Visibility is day unlimited and the tank is fully operational. CITV is available.

2. EXERCISE SUMMARY

| <u>Situation</u>      | <u>Type</u> | <u>Range</u> | <u>Tgt Velocity</u> | <u>Orientation</u> |
|-----------------------|-------------|--------------|---------------------|--------------------|
| 1                     | Tank        | 1790         | 19 MPH              | Full Right         |
|                       | BMP         | 1970         | 19 MPH              | Full Right         |
| -- 30 second interval |             |              |                     |                    |
| 2                     | Tank        | 2060         | 19 MPH              | 45 Right           |
|                       | BMP         | 1940         | 19 MPH              | Full Right         |
| -- 60 second interval |             |              |                     |                    |
| 3                     | Tank        | 1850         | 17 MPH              | Full Left          |
|                       | Tank        | 1590         | 19 MPH              | 45 Right           |
|                       | Tank        | 2010         | 22 MPH              | Front              |
| -- 30 second interval |             |              |                     |                    |
| 4                     | Helicopter  | 1900         | 36 MPH              | Front              |
|                       | Tan%        | 2050         | 16 MPH              | 45 Left            |
|                       | BMP         | 1700         | 22 MPH              | 45 Right           |

Test Exercise 945110  
Long Range, Moving Own Vehicle, Moving Target

1. SCOPE

The crew, operating a moving tank, engages multiple moving targets located from 1470-1790 meters. Visibility is day unlimited and the tank is fully operational. CITV is available.

2. EXERCISE SUMMARY

| <u>Situation</u>      | <u>Type</u> | <u>Range</u> | <u>Tgt Velocity</u> | <u>Orientation</u> |
|-----------------------|-------------|--------------|---------------------|--------------------|
| 1                     | Tank        | 1600         | 22 MPH              | Full Left          |
|                       | Tank        | 1750         | 23 MPH              | 45 Right           |
|                       | Tank        | 1480         | 26 MPH              | 45 Right           |
| -- 30 second interval |             |              |                     |                    |
| 2                     | BMP         | 1710         | 19 MPH              | 45 Right           |
|                       | Tank        | 1640         | 17 MPH              | 45 Right           |
|                       | Helicopter  | 2050         | 33 MPH              | 45 Left            |
| -- 60 second interval |             |              |                     |                    |
| 3                     | Tank        | 1470         | 27 MPH              | 45 Right           |
|                       | Tank        | 1640         | 20 MPH              | Full Right         |
| -- 30 second interval |             |              |                     |                    |
| 4                     | Tank        | 1580         | 17 MPH              | Full Left          |
|                       | BMP         | 1790         | 22 MPH              | 45 Right           |

Test Exercise 943210

Long Range, Moving Own Vehicle, Stationary Target

1. SCOPE

The crew, operating a moving tank, engages multiple moving targets located from 700-1700 meters. Visibility is day unlimited and the tank is fully operational. CITV is available.

2. EXERCISE SUMMARY

| <u>Situation</u>      | <u>Type</u> | <u>Range</u> | <u>Motion</u> | <u>Orientation</u> |
|-----------------------|-------------|--------------|---------------|--------------------|
| 1                     | Tank        | 1710         | Stationary    | 45 Left            |
|                       | Tank        | 1580         | Stationary    | Full Right         |
| -- 30 second interval |             |              |               |                    |
| 2                     | BMP         | 1680         | Stationary    | Full Right         |
|                       | Tank        | 1770         | Stationary    | 45 Right           |
| -- 60 second interval |             |              |               |                    |
| 3                     | BMP         | 1580         | Stationary    | Full Left          |
|                       | Troops      | 700          | Stationary    | 45 Right           |
|                       | Tank        | 1520         | Stationary    | 45 Right           |
| -- 30 second interval |             |              |               |                    |
| 4                     | Helicopter  | 1670         | Stationary    | Full Right         |
|                       | BMP         | 1590         | Stationary    | 45 Right           |
|                       | BMP         | 1640         | Stationary    | Front              |

# APPENDIX D

## Summary Data for Performance Measures

Table D-1

Means and Standard Deviations for First Engagement Time by Group  
(Seconds)

| Engagement        |    | Group  |         |
|-------------------|----|--------|---------|
|                   |    | CITV   | NO CITV |
| Stationary Tank   |    |        |         |
| Stationary Target | M  | 14.505 | 14.990  |
| Short Range       | SD | 3.705  | 2.750   |
| Stationary Tank   |    |        |         |
| Moving Target     | M  | 17.650 | 16.425  |
| Short Range       | SD | 4.492  | 4.963   |
| Moving Tank       |    |        |         |
| Stationary Target | M  | 12.915 | 13.810  |
| Short Range       | SD | 4.099  | 3.634   |
| Moving Tank       |    |        |         |
| Moving Target     | M  | 14.245 | 16.545  |
| Short Range       | SD | 4.355  | 4.305   |
| Stationary Tank   |    |        |         |
| Stationary Target | M  | 14.660 | 18.280  |
| Long Range        | SD | 3.470  | 4.152   |
| Stationary Tank   |    |        |         |
| Moving Target     | M  | 19.285 | 20.945  |
| Long Range        | SD | 5.493  | 3.810   |
| Moving Tank       |    |        |         |
| Stationary Target | M  | 14.865 | 16.805  |
| Long Range        | SD | 3.520  | 5.762   |
| Moving Tank       |    |        |         |
| Moving Target     | M  | 17.710 | 17.330  |
| Long Range        | SD | 4.349  | 6.242   |

Table D-2

Means and Standard Deviations for Subsequent Engagement Time by Group

| Engagement        |           | Group  |         |
|-------------------|-----------|--------|---------|
|                   |           | CITV   | NO CITV |
| Stationary Tank   |           |        |         |
| Stationary Target | <u>M</u>  | 32.305 | 40.135  |
| Short Range       | <u>SD</u> | 6.806  | 4.497   |
| Stationary Tank   |           |        |         |
| Moving Target     | <u>M</u>  | 40.430 | 42.660  |
| Short Range       | <u>SD</u> | 7.568  | 5.448   |
| Moving Tank       |           |        |         |
| Stationary Target | <u>M</u>  | 37.265 | 42.370  |
| Short Range       | <u>SD</u> | 7.265  | 3.936   |
| Moving Tank       |           |        |         |
| Moving Target     | <u>M</u>  | 43.050 | 45.580  |
| Short Range       | <u>SD</u> | 5.654  | 2.773   |
| Stationary Tank   |           |        |         |
| Stationary Target | <u>M</u>  | 36.760 | 40.495  |
| Long Range        | <u>SD</u> | 6.068  | 3.784   |
| Stationary Tank   |           |        |         |
| Moving Target     | <u>M</u>  | 43.560 | 46.260  |
| Long Range        | <u>SD</u> | 4.214  | 1.997   |
| Moving Tank       |           |        |         |
| Stationary Target | <u>M</u>  | 42.905 | 44.825  |
| Long Range        | <u>SD</u> | 2.403  | 2.090   |
| Moving Tank       |           |        |         |
| Moving Target     | <u>M</u>  | 42.680 | 45.325  |
| Long Range        | <u>SD</u> | 3.091  | .868    |

Table D-3

Means and Standard Deviations for Target Accuracy (Root Mean Square) by Group

| Engagement        |           | Group  |         |
|-------------------|-----------|--------|---------|
|                   |           | CITV   | NO CITV |
| Stationary Tank   |           |        |         |
| Stationary Target | <u>M</u>  | .766   | .743    |
| Short Range       | <u>SD</u> | .241   | .255    |
| Stationary Tank   |           |        |         |
| Moving Target     | <u>M</u>  | 1.215  | 9.652   |
| Short Range       | <u>SD</u> | .305   | 26.580  |
| Moving Tank       |           |        |         |
| Stationary Target | <u>M</u>  | 1.278  | 1.808   |
| Short Range       | <u>SD</u> | .365   | 2.146   |
| Moving Tank       |           |        |         |
| Moving Target     | <u>M</u>  | 1.208  | 1.326   |
| Short Range       | <u>SD</u> | .427   | .841    |
| Stationary Tank   |           |        |         |
| Stationary Target | <u>M</u>  | .609   | .648    |
| Long Range        | <u>SD</u> | .165   | .241    |
| Stationary Tank   |           |        |         |
| Moving Target     | <u>M</u>  | 8.458  | 1.219   |
| Long Range        | <u>SD</u> | 24.600 | .575    |
| Moving Tank       |           |        |         |
| Stationary Target | <u>M</u>  | 1.946  | 2.009   |
| Long Range        | <u>SD</u> | 2.727  | 2.707   |
| Moving Tank       |           |        |         |
| Moving Target     | <u>M</u>  | 1.020  | 1.289   |
| Long Range        | <u>SD</u> | .416   | 1.794   |



Table D-4

Means and Standard Deviations for Percent Targets Detected by Group

| Engagement        |    | Group |         |
|-------------------|----|-------|---------|
|                   |    | CITV  | NO CITV |
| Stationary Tank   |    |       |         |
| Stationary Target | M  | 96.50 | 82.50   |
| Short Range       | SD | 6.71  | 11.18   |
| Stationary Tank   |    |       |         |
| Moving Target     | M  | 88.00 | 78.00   |
| Short Range       | SD | 15.42 | 17.95   |
| Moving Tank       |    |       |         |
| Stationary Target | M  | 83.50 | 73.50   |
| Short Range       | SD | 12.68 | 10.40   |
| Moving Tank       |    |       |         |
| Moving Target     | M  | 65.00 | 55.00   |
| Short Range       | SD | 10.54 | 18.77   |
| Stationary Tank   |    |       |         |
| Stationary Target | M  | 83.50 | 74.50   |
| Long Range        | SD | 14.24 | 17.31   |
| Stationary Tank   |    |       |         |
| Moving Target     | M  | 77.50 | 66.00   |
| Long Range        | SD | 19.16 | 19.30   |
| Moving Tank       |    |       |         |
| Stationary Target | M  | 61.50 | 52.00   |
| Long Range        | SD | 11.82 | 13.22   |
| Moving Tank       |    |       |         |
| Moving Target     | M  | 66.00 | 55.00   |
| Long Range        | SD | 15.69 | 13.57   |

Table D-5

Means and Standard Deviations for Percent Targets Killed by Group

| Engagement        |           | Group |         |
|-------------------|-----------|-------|---------|
|                   |           | CITV  | NO CITV |
| Stationary Tank   |           |       |         |
| Stationary Target | <u>M</u>  | 93.50 | 80.00   |
| Short Range       | <u>SD</u> | 9.33  | 12.57   |
| Stationary Tank   |           |       |         |
| Moving Target     | <u>M</u>  | 84.50 | 71.00   |
| Short Range       | <u>SD</u> | 13.56 | 21.50   |
| Moving Tank       |           |       |         |
| Stationary Target | <u>M</u>  | 73.00 | 68.00   |
| Short Range       | <u>SD</u> | 13.80 | 12.81   |
| Moving Tank       |           |       |         |
| Moving Target     | <u>M</u>  | 63.50 | 50.50   |
| Short Range       | <u>SD</u> | 14.96 | 17.61   |
| Stationary Tank   |           |       |         |
| Stationary Target | <u>M</u>  | 79.00 | 70.00   |
| Long Range        | <u>SD</u> | 15.86 | 19.19   |
| Stationary Tank   |           |       |         |
| Moving Target     | <u>M</u>  | 74.50 | 42.00   |
| Long Range        | <u>SD</u> | 12.76 | 19.36   |
| Moving Tank       |           |       |         |
| Stationary Target | <u>M</u>  | 47.00 | 38.50   |
| Long Range        | <u>SD</u> | 13.80 | 11.37   |
| Moving Tank       |           |       |         |
| Moving Target     | <u>M</u>  | 62.50 | 50.50   |
| Long Range        | <u>SD</u> | 16.18 | 15.72   |

# APPENDIX E

## Correlations Between Performance Measures and Biographical Variables

| Performance Measure  | Biographical Measure |                 |                    |                        |
|----------------------|----------------------|-----------------|--------------------|------------------------|
|                      | TC GT Score          | Gunner GT Score | TC Time in Service | Gunner Time in Service |
| CITV # Identified    | 0.04                 | -0.07           | -0.14              | 0.03                   |
| CITV # Kills         | 0.07                 | -0.13           | -0.09              | -0.06                  |
| CITV RMS             | -0.01                | 0.03            | 0.02               | 0.44                   |
| CITV First Fire      | -0.15                | -0.12           | 0.08               | -0.32                  |
| CITV Subsequent      | -0.10                | 0.33            | 0.06               | -0.03                  |
| No CITV # Identified | 0.08                 | -0.38           | -0.36              | -0.48                  |
| No CITV # Kills      | 0.31                 | -0.35           | -0.33              | -0.37                  |
| No CITV RMS          | -0.03                | 0.12            | 0.24               | 0.56                   |
| No CITV First Fire   | -0.19                | 0.39            | 0.33               | 0.15                   |
| No CITV Subsequent   | -0.11                | 0.40            | 0.34               | 0.42                   |

APPENDIX F

Human Factors/Training Questionnaire

TANK COMMANDER

1. Did the CITV help or hurt your performance?

Circle one

Help

Hurt

NA

2. List the advantages of the CITV.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

3. List the disadvantages of the CITV.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

4. I found the Auto Scan to be a useful function on the CITV.

Circle one

Yes

No

5. The location of the CITV display is in a place where it will be most useful to me in target acquisition and allow me to accomplish my tasks as a TC.

Circle one

AGREE

DISAGREE

6. As compared to other sights that I use, the CITV display screen had too much information for me to pay attention to.

Circle one

Yes

No

If yes, what could you do without? \_\_\_\_\_

\_\_\_\_\_

7. The commands used for target handoff with the CITV were adequate.

Circle one

AGREE

DISAGREE

If you disagree, what alternative commands or changes to the display would you suggest?

---

---

---

---

8. The lighting on the control panel allows me to see all of the switches on the control panel easily.

Circle one

Yes

No

9. As compared to the way that I command a tank now, I found it easy to get lost or disoriented during the exercises.

Circle one

Yes

No

If yes, when?

- a. Day
- c. Moving

- b. Night
- d. Stationary

10. The orientation icon was useful in helping me to find myself on the battlefield.

Circle one

Yes

No

If you don't like the way the orientation icon functions, could you explain an alternative that would help you with orientation.

---

---

---

---

11. The commander's override handle, with the CITV functions, was easy for me to use.

Circle one

Yes

No

If you disagree, state your reasons.

---

---

---

12. Did you have any problems with the buttons/switches on the override handle?

Circle one

Yes

No

If yes, describe.

---

---

---

13. As compared to other systems on the tank, rate the complexity of this CITV. (Circle one)

1  
Simple

2

3  
Difficult

4

5  
Very Complex

14. What additional CITV controls do you think would make the system easier to use?

---

---

---

15. What capabilities do you feel the CITV lacks?

---

---

---

16. What changes would you recommend for the CITV or the procedures used?

---

---

---

17. After using the CITV for this period of time I felt as though my eyes were fatigued or stressed.

Circle one

Yes

No

If yes, at what point did you begin to feel the stress?

| <u>1/2 Hour</u> | <u>1 Hours</u> | <u>1 1/2 Hours</u> | <u>2 Hours</u> |
|-----------------|----------------|--------------------|----------------|
|-----------------|----------------|--------------------|----------------|

18. List any additional comments on the CITV's complexity, operation, capabilities, or anything in general not previously mentioned.

---

---

---

PT 5857

Summary of the Human Factors/Training Data

TANK COMMANDER    N=20

1. Did the CITV help or hurt your performance?

15 Help                      03 Hurt                      02 NA

2. List the advantages of the CITV.

10 Target acquisition

04 Quicker gun lay

04 Sectors of fire

3. List the disadvantages of the CITV.

09 Screen is too small

09 Thermal image is not well lit

06 Too many buttons

4. I found the Auto Scan to be a useful function on the CITV.

16 Yes

04 No

5. The location of the CITV display is in a place where it will be most useful to me in target acquisition and allow me to accomplish my tasks as a TC.

17 AGREE

02 DISAGREE

01 DON'T KNOW

6. As compared to other sights that I use, the CITV display screen had too much information for me to pay attention to.

01 Yes

19 No

If yes, what could you do without? NO ANSWER GIVEN

7. The commands used for target handoff with the CITV were adequate.

15 AGREE

03 DI'AGREE

02 NO ANSWER

If you disagree, what alternative commands or changes to the display would you suggest?

NO ANSWER GIVEN



8. The lighting on the control panel allows me to see all of the switches on the control panel easily.

16 Yes

04 No

9. As compared to the way that I command a tank now, I found it easy to get lost or disoriented during the exercises.

04 Yes

14 No

If yes, when?

00 Day

00 Night

04 Moving

00 Stationary

10. The orientation icon was useful in helping me to find myself on the battlefield.

18 Yes

02 No

If you don't like the way the orientation icon functions, could you explain an alternative that would help you with orientation?

Provide a similar icon for the gunner

11. The commander's override handle, with the CITV functions, was easy for me to use.

15 Yes

05 No

If you disagree, state your reasons.

(4) Override in uncomfortable position

12. Did you have any problems with the buttons/switches on the override handle?

04 Yes

16 No

If yes, describe. (04) Difficulty knowing which mode is operational (e.g. CITV vs. Turret)

13. As compared to other systems on the tank, rate the complexity of this CITV.

1  
Simple

2

3  
Difficult

4

5  
Very Complex

(09)

(07)

(04)

14. What additional CITV controls do you think would make the system easier to use?

(03) Move the magnification switch to a more accessible location

15. What capabilities do you feel the CITV lacks?

(04) Magnification should be 10X to 20X

(04) Sight should also have day capability

(03) System needs better thermal imaging capability

(03) More screen clarity

(02) Full 360° rotation

16. What changes would you recommend for the CITV or the procedures used?

(02) Eliminate the Auto Scan function

(02) Provide a means to determine direction and distance of main gun slew

(04) Reduce the number of switches

(04) Locate the magnification switch in a more accessible place

(04) Redo the rate set procedure so that it can be set only with the increase and decrease switches

(04) Consider using the increase/decrease rheostats currently in the tank instead of the push buttons

17. After using the CITV for this period of time I felt as though my eyes were fatigued or stressed.

03 Yes

17 No

If yes, at what point did you begin to feel the stress?

1/2 Hour

1 Hours

1 1/2 Hours

2 Hours

01 3/4 hour

01 1 hour

01 2 hours

18. List any additional comments on the CITV's complexity, operation, capabilities, or anything in general not previously mentioned.

(02) How am I supposed to do everything a TC is to do if I'm looking at a screen?

(02) This will cause a big change in the way we train

(02) It was confusing to use the override for both the turret and CITV controls

(03) It may be difficult for many TCs to let the gunner assess the kills

(04) I didn't get lost in the U-COFT but I probably will in the field

(04) The system is really difficult to use on the move

**END  
FILMED**

DATE:  
**12-90**

**DTIC**